Advances in Educational Technology and Psychology, ISSN 2371-9400
2021 5th International Seminar on Teaching and Advances in Education
Vol. 25, 2021, pp. 27-30

Discussion on the Significance of Physics Textbook for Education Based on 'Lenz Double ring experiment'

Jiamin Wan

School of Jiangxi, Normal University, Nanchang 330022, China

ABSTRACT. This paper starts from a controversial after-class question in the high school physics textbook, discussing the significance of the textbook for teachers to carry out the physics class. The phenomenon of 'Lenz double ring experiment' in the textbook seems to reflect the content of section learning and the effect of "come to reject but go to retain" in the Lenz law. However, the actual practice has some deviations from the content of the textbook. By considering the causes of deviations and 'moving' or 'not moving' of the double ring, I have some thoughts about physics education. As a teacher, we should not only make good use of the teaching material resources (for example the physics textbook), but also modify or adjust the content of the teaching material appropriately according to the actual physics class. Moreover, we can cultivate the scientific inquiry ability in the physics core literacy according to the textbook, and effectively internalize the scientific inquiry method into the physical thinking quality of students.

KEYWORDS: 'lenz double ring experiment', Physics textbook, Education, Physics core literacy

1. Introduction

All these days, whether students or teachers, they regard the physics textbooks as the whole. Thus, they take in the knowledge and exercises of the textbook totally and uncritically without thinking. Under the standards of the new curriculum, teaching materials are no longer the only curriculum resources, and students' cognitive errors and innovative thinking can also be used as curriculum resources, so that teachers become the creators of curriculum resources rather than the master of the class. This paper starts from a controversial experiment. Based on this experiment, the author will discuss how to prepare a good physics class under the new curriculum standard.

2. 'Lenz Double ring experiment' in Textbook

The course resource of 'Lenz double ring experiment' is from the after-class exercises of 'Lenz's Law' in The Selective Compulsory Course Ⅱ of high school Physics, as shown in Figure 1.1.

Both A and B are aluminum rings, ring A is closed, and ring B is disconnected, and the beam can rotate around the middle. In an experiment, when a person is in an experiment, any of the poles get close to the ring A , ring A will be redirected. When the magnet away from the ring A and ring A will be attracted by the magnet. But when the magnetic pole moves near or away from the ring B, it does not find the same phenomenon as the ring A. Why is that?

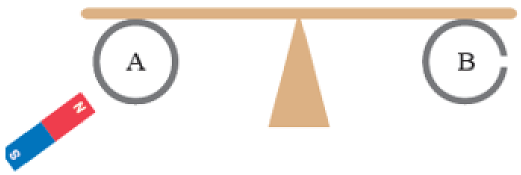

Fig.1 Shows the 'Lenz Double ring experiment' Exercise

According to Lenz's law, an induced current will be generated in ring A to prevent the magnet from approaching ring A. Similarly, when the magnet is far away from ring A, the direction of induced current generated in ring A prevents ring A from moving away from magnet. Since the ring b is disconnected, no induced current will be generated in the ring B whether the magnetic pole moves near or far away from it. So the ring B will not move. This shows that the magnetic field of the induced current always impedes the change of the magnetic flux causing the induced current, which reflects the effect of ‘Lenz's law’.

3. Deep Study of the ‘Lenz Double ring experiment’

The author is very interested in this experiment. After repeated experiments many times, I found that the disconnected ring B can move when the magnet is close to it. However, sometimes the ring A can't move. With a rigorous and realistic attitude to science, the author has read a lot of literatures, I found that the same question was discussed in the article ‘questioning the answer to an exercise in physics textbook’ in 2011: when the author adheres a neodymium super magnet to a normal magnet, ring B moves. Sometimes ring A does not move when the magnet is close to or away from the magnet, According to ‘Faraday's law of electromagnetic induction’, the induced electromotive force will still be generated in the ring B, and the generated eddy electric field will redistribute the free charge in the ring B. In the process of the charge redistribution, a short-term instantaneous current will be generated, and the interaction between the magnet and the instantaneous current will occur. Therefore, according to this reason, the author analogizes and carries on the experimental verification repeatedly. It is found that when a weak magnet is close to the closed ring A, A will remain still. When an ordinary magnet or even a super magnet is used, ring A will continue to move in a state of ‘come to reject but go to retain’. The disconnected ring B will move under the action of a super magnet.

The actual phenomenon of the experiment seems to violate the original purpose of the textbook because it cannot show the effect of the ‘Lenz's law’ which is ‘come to reject but go to retain’. However, this exercise has not been removed, instead, it has been retained in the textbook constantly adapted for more than ten years. I can't help thinking that under the new curriculum standard, we need to use a new way of thinking in the process of physical education.

4. Teaching Reflection of the Physics Textbook

4.1 Practice Makes Perfect.

First of all, the experiment in the textbook should be operated by hand before teachers demonstrate in the class. We cannot be an armchair strategist. It is because sometimes, the conclusion of the practical operation is different from the ideal situation. In that case, as this kind of experiment, the author refers to the previous researches, using three different magnets to carry out three groups of experiments with control variate method. I obtain different phenomena from the textbook:

(1) The experiment is carried out with a weaker magnet. When the weak magnet is close to ring A, the induced current generated in the ring will resist the increase of magnetic flux, which will produce a force to hinder the weak magnet from approaching. Due to the weak magnetism of the magnet, the force generated is too small, which is less than the friction force between the fulcrum and A, so it is not enough to make ring A move. And the force produced is too small to let ring B move.

(2) Bind two weak magnets together to do the experiment. In this case, a can move, B cannot move. This is the effect that the physics textbook is talking about. Because the magnetism of the two weak magnets is stronger than that of the first group of magnets.

(3) Use a super magnet. It shows that both ring A and B move. The reason why ring B moves has been described before.

4.2 Thinking Differences.

When there is a difference between the textbook and the actual phenomena, we should take the initiative to think about the causes of the difference rather than abandon the textbook blindly. The reason why we use the same device, having a different results is that the textbook discusses ‘loop immobility’, it is an idealized physical model for a complete loop. In the actual operation, ring B can move, which is a “transient” process for the actual situation. In this process, the charge orientation movement occurs due to electromagnetic induction, thus driving the ring B to move. This also verifies the difference between the ideal model and the actual situation. Therefore, when facing the teaching materials, we should take the initiative to think about the gap between the teaching materials and the reality, and we cannot draw a conclusion immediately without thinking. If we are satisfied with a smattering of knowledge, drawing the conclusion before we know the truth, it would not good for us and students to learn physics and form a rigorous scientific attitude.

4.3 Critical Thinking.

For front-line teachers, teachers must have a "critical thinking". They should not regard textbooks as the whole, but think about the connotation of the knowledge they teach actively. Teachers can carry out relevant experimental courses after finding out different situation from the textbook. This is a good 'trap' problem. If teachers want to summarize 'Lenz's law' through this experiment, there may be a phenomenon of ring B-action or ring A-motionless. If teachers can grasp the "trap" of this exercise and guide the students to discover, explore and correct the errors, it will not only deepen the students' understanding and mastery of the "Lenz law", but also enhance the students' critical and in-depth consciousness. So that, it would play an unexpected and unique role.

4.4 Adjust the Content of the Textbook.

Teachers can adjust the content or order of teaching materials according to the actual situation. In this experiment, although the reasons behind the phenomenon have deviated from the content of this section, they can be explained with basic high school electromagnetic knowledge, which is not beyond the ability of high school students. The disconnected ring can move because of the 'vortices', which will learn in the later section. In this way, instead of studying a particular section in isolation, the students string together the 'Lenz's law' from the first section and the 'vortices' from the later sections. Not only did the students learn the basic knowledge more firmly, but also the ability to analyze and solve problems was trained again. So the 'Lenz double ring experiment' is a wonderful course resource for teachers to exploit and design the unusual physics classes.

4.5 Design Experiments.

Finally, the teacher should try to design and explore the experimental content reasonably, so as to cultivate the students' ability of thinking and experimental inquiry. In the experimental class, the teacher 'throws out a minnow to catch a whale' and puts forward a series of questions for students to think. After the experiment, the students can guess the reason why this phenomenon occurs and what the influencing factors are. For this experiment, After confirming that this phenomenon is independent of the size, thickness, and insertion mode of the aluminum ring, we further explored the effect of magnetic magnetism on the experiment. After the teacher explain the reason and introduce the 'vortices', students can understand and connect the whole chapter. Although the proportion of the experimental part has increased in the current textbooks, most of the experiments are still confirmatory, and the results of the confirmatory experiments can be predicted. So the students do not have much curiosity and interest in them, Only when the students are in the dominant position, can they really experience the process of 'asking questions - guessing and hypothesizing - making plans and designing experiments - conducting experiments and collecting data - analyzing and demonstrating – Evaluating', can students' scientific inquiry ability be really improved.

5. Conclusion

'Ask canal that get so clear, to have source running water to come'. Teachers are not only the recipients of the curriculum, but also the debuggers and creators of the curriculum. Therefore, it is particularly important for teachers to develop curriculum based on the textbooks. Although textbooks are no longer the only curriculum resources, they are still the most basic curriculum resources. Teachers should think independently before using textbooks. We should not only excavate the teaching materials deeply, find out the resources that can be reused in the textbooks, carry out the integration and development, avoid the formalism of teaching, but also creatively develop and utilize other teaching resources, and pay attention to the unexpected problems which are raised by students. Because these problems reflect students' interest, enthusiasm and thinking mode. Therefore, only by grasping the source of teaching materials can we achieve good teaching effect.

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