The Practice Research of “Heuristic Teaching” in “Circuit Theory”

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Keywords: Heuristic teaching; circuit theory; “using one against three”; complex frequency domain

Abstract. The processing of dynamic process in the course of circuit theory is a difficult problem in the study of students. The main reason is the complex frequency domain volt-ampere relation and the model of the dynamic component cannot be understood. “Heuristic teaching” can effectively mobilize students’ subjective initiative. The innovative ability of students can be improved and the approaches to the problem can be mastered by engaging students directly exploring teaching. Eventually the education purpose of “using one against three” can be achieved. Through derivation process of the frequency domain volt-ampere relation and the model of inductance component, the complex frequency domain volt-ampere relation and the model of the dynamic component are obtained by “heuristic teaching” in this paper. It is proved that the result for teaching practice by the practical application of the circuit theory course is good.

1. Introduction

The main content of “Circuit theory” is the analysis of electromagnetic phenomena in the circuit, the research of basic law and analysis method of the circuit. It is an important technical basic course of electrical and electronic information major in institution of higher learning. This course is a preliminary foundation for further study of circuit theory. In this course, necessary circuit knowledge can be achieved for subsequent courses. It plays an important role of talent training scheme and curriculum system in the whole electrical and electronic and information major [1]. In the teaching practice, new series circuit theory courses system of “fundamental theory of circuit, circuit experiment, computer aided analysis of the circuit and circuit professional foreign language reading” was built by “circuit theory teaching research group” in our school. Teaching mode of “classroom teaching, computer-assisted autonomous learning, student cooperation and teacher guidance” was formed. Especially the application of heuristic teaching, example teaching, constructivism teaching theory and many other advanced teaching theories in teaching has obtained good effects. This paper mainly discusses the practice research of “heuristic teaching” in the course of circuit theory.

2. Heuristic Teaching [2-6]

“Heuristic teaching” refers to a teaching method of leading students to grasp the knowledge initiatively, actively and conscientiously by using a variety of ways. According to the teaching task and the objective law of learning, the teacher inspires students’ thinking in light of the students’ needs.

Heuristic teaching has long been studied both at home and abroad. Confucius, one of the most famous educationists in ancient China, said, “In teaching process, the teacher ought to get the right point to conduct students, neither too fast nor too slow.” After Confucius, the author of the book “Records of Learning” put forward, “guidance without teaching, strictness without depression, enlightenment without telling the result”, which further elucidates the idea of heuristic teaching. The ancient Greek thinker Socrates used the “question and answer method” to enlighten the students on their independent thinking to explore the truth. The German educator J.F. Herbart promoted students’ existing experience and knowledge as a starting point for learning, which was
called heuristic pedagogy. He thought that people always use the consciousness of existing old “concept” to melt, absorb new “concept”. And students can follow by the teacher teaching process to inspire their thought, promote the system of knowledge, cultivate of reasoning ability. W. Ryan further proposed the “five formal lesson-steps” in heuristics. The schematic diagram is shown in Fig. 1.

Figure 1. “Five formal lesson-steps” schematic diagram.

The “preparatory” stage requires students to have the relevant prior knowledge. The teacher only needs to ask questions, and students will use the existing knowledge to answer the questions. Students are the subjects at this stage. In “Presentation” stage, the teacher guide students to explore how to use the old knowledge to solve “new problem 1”. At this stage, the teacher should pay attention to strengthen the interaction with students. The teaching method of “question and answer” suits better in this stage, the teacher and students are both the main body. Stage “comparison” needs to put forward a “new problem 2” associated with the “new problem 1” in upper stage. The teacher should concentrate on the similarities of two kinds of new problems, this stage the teacher are the main body. The “summarization” stage consists of students recognizing that the two new problems that have been learned in the preceding stage belong to one class. And the general method for solving such problems is initiated by the students, which are the main body. At “Application” stage, students solve “new problem 2” independently on the basis of inductive conclusion in the previous stage, and realize that this conclusion can be transformed into similar “new problem 3”, “new problem 4”.

The teaching process of “heuristic teaching” can be long or short, which is determined by “new problem 1” and “new problem 2” in the teaching arrangement. Sometimes these five stages can be completed in one class, and sometimes it takes a long time to complete the process.
3. The Application of Heuristic Teaching in Circuit Theory

According to the circuit theory, the analysis of direct current circuit is carried out in the time domain. The frequency domain analysis (phase method) is developed in order to overcome the complexity of the differential equation in time domain analysis. In the same way, when analyzing the linear dynamic circuit, the solution process is greatly simplified from time domain to complex frequency domain analysis (operation method). This paper introduces the application of “heuristic teaching” in circuit theory based on derivation process of the volt-ampere relation between the frequency domain and complex frequency domain and the model of inductance components.

3.1 Teaching Process.

1. Teaching stage 1: preparation stage. The teacher put forward “new problem 1”, namely deduce the frequency domain volt-ampere relation and the model of inductive components. The time domain and time domain models of the component are recalled by the students such as formula (1) and Fig. 2 respectively.

   \[ u_L(t) = L \frac{di_L(t)}{dt} \]  
   
   \[ \text{Figure 2. The time domain model of the inductive element } L. \]

2. Teaching stage 2: prompt stage. How to obtain the frequency domain volt-ampere relation of L based on the time domain volt-ampere relation? Under the guidance of the teacher, it is realized by students that the opposite ends of the formula (1) can achieve the purpose. The frequency domain volt-ampere relation is given by formula (2).

   \[ U_L = j\omega L i_L \]  
   
   \[ \text{On the basis of type (2), the frequency domain model of L is shown in Fig. 3.} \]

   \[ \text{Figure 3. The frequency domain model of the inductive element } L. \]

3. Teaching stage 3: comparison stage. The teacher puts forward the “new problem 2”, which is to derive the volt-ampere relation and the model of the inductive element L. This stage should emphasize the similarities between the “new problem 1” solved and the “new problem 2” to be solved. Frequency domain volt-ampere relation and the model of circuit components are proposed to solve the problem of sinusoidal steady state. And complex frequency domain volt-ampere relation and the model are put forward in order to solve the problem of linear dynamic. However, both of them are obtained on the basis of its time domain volt-ampere relation and model. In the teaching arrangement of “circuit theory”, this part and the first two teaching stages are separated by a number of periods, and the teacher can lead the students to review the “new problem 1”.

4. Teaching stage 4: overview stage. Through review, students can easily clarify the train of thought which is shown in Fig. 4.
Combined with “three stages” in the interpretation of similarities between “new problem 1” and “new problem 2”, the complex frequency domain volt-ampere relation and the model of L can be inductively obtained by students. The thought process of derivation is shown in Fig. 5.

At this point, students have been able to independently carry out the derivation of the volt-ampere relation and model of circuit elements in time domain, frequency domain and complex frequency domain. This method can also be extended to other circuit elements.

3.2 Teaching Effect.

With “heuristic teaching” in the teaching process, the biggest benefit for the students is to master the way to solve such problems. Meanwhile, this method can be used to guide future studies, not only to remember a simple conclusion. It is exactly the purpose of the education. The teaching practice proves that students not only remember the above teaching process, but also have a good understanding of it.

4. Conclusion

There is a saying in Chinese which says it is always better to teach a person who are hungry to fish than to give him some fish. In the process of teaching, the teacher should guide students step by step to master the methods to solve the problem, and let students directly be involved in exploring teaching. Students’ subjective initiative should be given to full play. Their innovation ability should
be developed. And the ability to master the scientific method should be cultivated. “Heuristic teaching” is a good way to explain this. It is also a good way for the teacher to give students the “mysterious finger” which can “make a stone into gold when touching it”.

5. Acknowledgment

This paper is subsidized by North China Electric Power University (Baoding) central university education teaching reform special project, and North China Electric Power University (Baoding) excellent young teacher teaching support scheme.

6. References


