

# A Report on the Results of Electric Circuit Concept Survey Tests in the Teacher Training Course, from 2001 to 2020.

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**Abstract.** We carried out a survey test of the concept of electric circuit to investigate the understanding of these concepts at primary school level by students on teacher training courses for 20 years. The results shows that students were not able to understand simple circuits, although improvements in textbooks and curricula used in primary schools. The lack of understanding of the circuit itself and of the inner workings of a bulb was evident. Further analysis revealed that there is an increasing number of people who do not care about the internal structure of the bulb.

## 1 Introduction

While teaching a university teacher training course on how to learn electric circuits, we were surprised by the lack of knowledge of the students. So we started to investigate the concepts of electric circuits[1] around 2000. Specifically, they did not understand that a closed circuit is a continuous loop, which should be taught in primary school, they did not distinguish between the conductor and the insulator of a bulb, and as a result, short circuits were often drawn by them. [2] It came as a shock that they should have such a problem, despite the fact that they were the high-performing students who had passed the entrance examination for the National University. This is because they will soon become teachers in primary and secondary schools, teaching electric circuits and electromagnetism.

In Japan, third graders (9-year-olds) are the first to learn about electric circuits. They are supposed to learn the basics of circuits and the difference between conductors and insulators in a very simple circuit - a battery, a light bulb and some lead wires. We insisted that the inner workings of a light bulb be taught through experiments, with an awareness of the difference between conductors and insulators, and as a result the textbook and curriculum were improved in the mid-2000s. It would be very interesting to see how the children who studied at that time have changed over the past 10 years when they enter university. The motivation for this study is to examine whether the results of individual questions have changed and whether the improvements in textbooks and curriculum have had an effect.

## 2 Changes over time in the conceptual survey at university

A survey of the electrical circuit concepts of students on teacher training courses is carried out annually. The results (left pannel of Figure 1) show that there is actually no outstanding change from previous years. There has been no expected improvement since around 2016, in fact there has been a decline. The percentage of students answering questions No.5 and No.6 correctly has fallen by around 20 points in the last 10 years. Parallel circuits/series circuits, for example, stood out in comparison to the lesser changes.

The survey was conducted again at one high level high school in 2020. The results were very

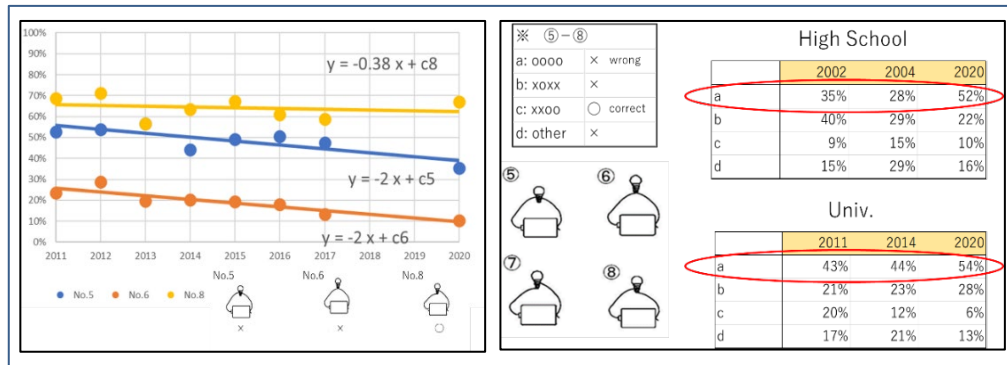


Fig. 1 Typical results of survey test, percentage of correct answers of each year (left), and answering pattern (c is correct) in high school and university (right)

similar to those of the universities. For reasons of space, we will not go into the details here, but it is noted that the survey included further questions, for example the difference in power consumption between parallel and series circuits mentioned above.

### 3 What the results show

Let us now return to Figure 1 and look at the results carefully. For questions No.5 and No.6, the majority of the answers were "o" (light up) in 2020. No.5 and No.6, together with No.7 and No.8, were also analyzed to see what kind of answer pattern they had. As you can see in Figure 1(right), the majority of the students answered that all the lights were on. At the same time as the number of students answering that No.6 lights up is increasing, the number of students who think that it lights up if it is somehow connected to the non-glass body part of the bulb is also increasing. This implies that the majority of them do not care or cannot pay attention to the internal structure of the bulb anymore. The recent change in lifestyle may have contributed to the shift to LED, whose internal structure cannot be observed. This seems to be an important point of view when considering how to teach and assess electrical circuits in the future.

### 4 Conclusion

Over a period of 20 years, a survey of the concepts of electric circuits was carried out to investigate the understanding of these concepts at primary school level by students on teacher training courses. The results revealed that, as was the case 20 years ago, students were not able to understand very simple circuits. This is despite improvements in textbooks and curricula used in primary schools, and in fact the scores have fallen. The lack of understanding of the circuit itself, of conductors and insulators, and of the inner workings of a light bulb was evident. Further analysis revealed that there is an increasing number of people who do not care about the internal structure of the bulb.

### References

- [1] Our concept survey test is based on the idea of famous tests by R. Osborne. See, R. Osborne and P. Freyberg, "Learning in Science: The Implications of Children's Science". Auckland: Heinemann. (1985).
- [2] N. Takahashi, *et al.* Misconception in the Electric Circuit and the Conductor, ICPE 2005 in India.