# The Transformer as a Knowledge Integration Tool For Teaching Electromagnetism

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**Abstract**

The transformer is a central component of the power supply system. A review of textbooks shows that a transformer is used only to demonstrate the subject of magnetic induction, and focused on the voltage conversion mechanism determined by the ratio of the wraps between the two sides of the transformer. This approach does not address students' difficulties regarding the energy transfer mechanism in a transformer.

Here we will demonstrate how the physical basis of the transformer can be used to foster an integration of the conceptual knowledge of electromagnetism and thus to be regarded as a Knowledge Integration Tool (KIT)

**Introduction**

In introductory physics textbooks, the transformer is usually mentioned at the end of the chapter dealing with magnetism. The transformer enables authors to demonstrate the use of Faraday's Law in the context of an electricity transmission system. In this system, it is necessary to transfer a lot of energy from the power plant to the consumers. Since the home operating voltage is 220v (110v in the US), high current is required to maintain the required power. However, high current will cause a great loss of energy across the transmission lines. The transformer solves this problem by changing the currents and voltage ratio (in opposite directions) at both the power plant end and the consumers (the city) end.

For an ideal transformer (fig.1), Faraday's Law gives the relationship between the wraps ratio and the voltages and currents ratio on both sides of the transformer:

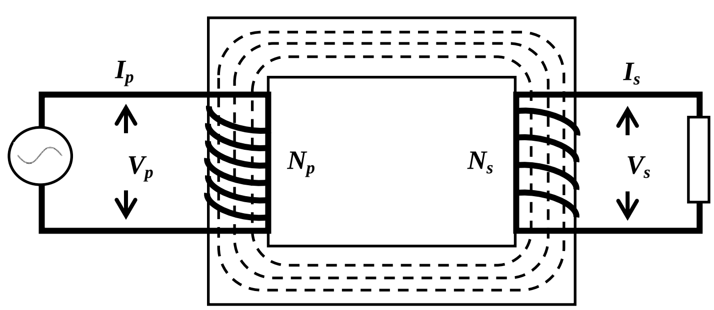


Fig. 1 Schematic transformer structure

In equation 1, it can be seen that when $N_p < N_s$ the wraps ratio lowers the voltage from the primary side to the secondary side, and the current is increased by the same ratio.

$$\frac{I_s}{I_p} = \frac{V_p}{V_s} = \frac{N_p}{N_s} \quad (1)$$

In our experience, the basic description of the transformer mechanism leaves students (and sometimes teachers) with several difficulties:

- This explanation does not give full insight how changing the resistance on the secondary side of the transformer changes (by feedback) the power provided by the source on the primary side of the transformer. This can be related to many student's difficulties in recognizing that the battery's power supply depends on the characteristics of the whole circuit.
- The current-voltage inverse ratio seems for many students to contradict what they have learned with regard to Ohms law. The current approach does not appear to assist them in reconciling this apparent contradiction.

In order to address these difficulties, we suggest to introduce the concept of impedance. We will show then how the transformer can be used as a pedagogical tool for inducing knowledge integration as it can assist in clarifying the relationship and differences between basic concepts of electricity and magnetism. Fostering such an integration of knowledge is highly important since it was shown that students who study basic physics courses do not have the ability to make conceptual integration between all the pertinent concepts and principles [1],[2],[3].

In our presentation, we will demonstrate how the transformer can be used as an instruction tool both in terms of the physical point of view (by fields and flux), and from the engineering point of view of impedances and resistances. Our approach will address the two difficulties described above.

We will then describe the general features of such a teaching approach tool in fostering the four interrelated knowledge integration processes that have been suggested by Linn and Eylon [5] [6]. We will generalize this insight for other examples which use an artifact as a **knowledge integration tool** (**KIT**).

## References


[1] F. Reif, “Millikan Lecture 1994: Understanding and teaching important scientific thought processes,” American Journal of Physics, 63, pp. 17-32, 1995.

[2] E. Bagno & B. S. Eylon, “From problem solving to a knowledge structure: An example from the domain of electromagnetism,” American Journal of Physics, 65, p. 726–736, 1997.

[3] F. Reif, Applying Cognitive Science to Education, Cambridge, Massachusetts: MIT Press, 2008.

[4] R. Resnick, D. Haliday & J. Walker, Fundamentals of Physics (9th edition), New Jersey: John Wiley & Sons, Ins., 2011.

[5] M. C. Linn & B. S. Eylon, Science education: Integrating views of learning and instruction. In P. A. Alexander & P. H. Winne (Eds.), Handbook of Educational Psychology, 2 , Edited, Mahwah, NJ: Erlbaum, 2006, pp. 511-544.

[6] M. C. Linn & B. S. Eylon, Science learning and instruction: Taking advantage of technology to promote knowledge integration, New York, NY: Routledge, 2011.