

Figure 6. Study of the Black Box, using the ohmmeter as an instrument

0-60 min: Students work in groups, handle materials, discuss, keep notes			60-90 min: Discussion in the plenary, conducted by the instructor		
Points connected on terminals 1 & 2	Observations	Desired/ideal inferences from students	Questions to unveil students' inferences from observations	Key points resulting from plenary discussion on students' inferences	NOSK aspects brought out from key points
A-B	8.2Ω	• The previous connections from the buzzer are verified • According to ohmmeter's indications, two inferences could be made for the three sides of triangle EIH: 1) resistors are only on sides EI and HI, equal to 24.7Ω and 8.2Ω respectively. Resistance of HE (32.8Ω) equals to the sum of those (±0.1Ω measurement uncertainty) and 2) there are proper resistors in all sides of the triangle (see appendix) • The observation that in any conductive connection the resistance equals to 8.2Ω per 5cm, could lead to the hypothesis that resistance is proportional to distance (see Appendix) • Verification of the above leads to the "Law": resistance equals to 8.2Ω/5cm in every conductive connection. The "Law" leads to the conclusion that no direct connection is between H-E, because their direct distance equals to 17cm and the measured resistance is 32.8Ω instead of 27.9Ω that should occur through the "Law". Thus, points H-E are connected through I, in 20cm total distance (EI=15cm+IH=5cm) and the expected resistance equals to 32.8Ω, the measured one.	• Are resistors on EI and HI or on all sides of the triangle EIH? • Is it possible to answer the question using only the instrument? If the instrument had an indication with more decimal digits, but the measurement uncertainty is always ±1 in the last digit, could we get an answer? • What new options are given by the new instrument? • Where is the "Law" due?	• It is possible that some students reached only the first option and regard the problem solved. The second option need to be discussed in the plenary (even from the instructor) • The instrument cannot provide an answer (see Appendix) • New instruments enable more precise formulation and control of hypothesis • For instance, it could be due to conductor's resistance per unit length or due to resistors of appropriate value. Also, it is interesting whether the "elementary/quantum" unit is the 8.2Ω-resistor or there are other values of resistors connected properly to form the 8.2Ω	• Same observations might result to different inferences (A1) The initial subjective knowledge turns out to be more objective (A4) • A4 • A4 - Laws and Theories are different (A6). The researcher has a "Law", a mathematical relation, brought out as an inference from observations and creative thoughts, but without any explanation why it occurs. There is no Theory (A6)
B-C	8.3Ω				
A-C	16.4Ω				
E-I	24.7Ω				
E-H	32.8Ω				
E-G	32.9Ω				
I-H	8.2Ω				
I-G	57.6Ω				
G-H	65.7Ω				