



"Teaching Physics with Interdisciplinary Project Based Teaching and Learning (IPBTL) Model"

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ABSTRACT

Teaching Physics to Physics minors or non-Physics major is always challenging. In this article, an example of teaching Physics to working students using interdisciplinary project is shown. In other words, a teaching model called Interdisciplinary Project Based Teaching and Learning (IPBTL) is introduced with results found in class. The results showed that the model brought significant increase in students' interest of learning and understanding the depth of Physics and made them capable to connect knowledge of Physics with real world applications. As an example, the project ran in one semester of the Physics course called as "Applying Ohm's Law to the real world monetary coins i.e. Penny, Nickel, Dime and Quarter" is shown. This project was given to students who were learning the concept of electricity, and they work in the area of electricity.

Keywords: Physics, Interdisciplinary project, teaching model, Ohm's Law, Penny, Nickel, Dime, Quarter, Circuit, electricity, IPBTL, application.

INTRODUCTION

Teaching Physics to Physics minors and diverse students is always challenging. Some studies can be found where people focus on Problem Based teaching to increase students interest and involvement in the class¹⁻⁴. In these studies, some problem is given to the students to solve and a time is given to work in groups. At the end, students come to the answers and solutions of the problem. It is a nice way of creating an interacting classroom.

The present work focuses Interdisciplinary Project Based Teaching and Learning (IPBTL) where an interdisciplinary project is assigned to the class as a group where they are asked to use and explore the physical concepts learned in the class during this project and find its real-world application by performing some experiments related to their major or work area. It came out that students can understand the concepts of Physics in much easier way using IPBTL model. Hence, in the present work, we are showing details of an undergraduate project that was run in a basic Physics class in spring 2016 semester in a Physics course – Phys. 1035 with its results, outcomes and application.

MODEL AND PROJECT DETAILS

The IPBTL model encourages students to work beyond the physics classroom to engage in questions and research related to their majors or work areas. We describe the motivation for the model and the implementation and outcomes of the model, report on the impact on students, and suggest ways in which creativity can be encouraged in all science courses.

In WIT, the majority of students taking physics are engineering students and some of them are non-science major students or working students or Art students. Most of these students will work as engineers in various field, or in construction management or some in arts area. To give them depth of Physics knowledge, it is important to connect their major areas or work area with what they are learning in the classrooms. Specially, in Physics or science courses those are not directly connected to students' major areas of engineering or other disciplines, it is important to connect them with some short-term course projects. Thus, it is critical for students in these majors to understand the principles of physics which underlie the field of engineering, construction management, technology, or arts with real world applications.

To help ensure that students are leaving our institute with the above skills, I like to introduce a teaching model of Interdisciplinary Project Based Teaching and Learning Model (IPBTL). In this model, students in the class are given some ideas how to connect the topics being taught to the real world and their major areas and come up with some title of what to do in terms of a small project that is about 2-3 weeks long. Students work in groups, perform some experiments in laboratory and see how the results coming are consistent with what they do outside in the real world. Then they come up with results and conclusion and write a report and present their work in the class at the end of the course.

To see how effective is this model, a pretest and posttest is given to the class before and after project based on what they are learning in the course to see the depth of their learning. To assess their knowledge, three exams are given where one is given very early in the semester, second one during middle of semester and the last exam is towards the end of the semester and then grades are compared to see outcomes. It is found that grades of the entire class improved significantly with positive feedback given by students.

Here is an example of a project given to the Physics B class during spring semester who worked on Ohm's law of circuit and found how much each monetary coin have when tested in the Physics laboratory and how other electrical physical quantities can be studied and found using Ohm's law.

Ohm's law is one of the important Physical Laws in electricity and circuits and is taught in various types of Physics II courses. In this project, this law is taught in the class with its importance in electrical circuits and real-world applications. Each element of circuits was shown to students and asked to apply Ohm's law with real world objects and check its applicability. Four real world coins i.e. Penny, Nickel, Dime and Quarter were used in this project, shown in Figure 1. A certain voltage was applied across each coin and respective current flowing in the coin was measured. Later, resistance, resistivity, conductivity, electric field, current density was calculated for all coins. The goal of the project was set and shown below. The method followed during the project is also shown below.



Figure 1: Four real world coins used in the study i.e. Quarter, Nickel, Dime and Penney.

OBJECTIVES

- To understand the concept of measurement, Ohm's Law, electric field and electric circuit.
- To understand the relation between electric voltage and electric current across the coins made with metallic alloys.
- To find whether Ohm's law is applicable in a Penny, a Nickel, a Dime and a Quarter and find if their resistance can be measured within provided potential by power supply in Physics lab.
- To understand the connection of resistivity and conductivity of the coins with their resistances and its application in the real world.

METHODS

- The dimensions i.e. diameter, thickness of each coin was measured using Vernier Calipers, shown in Figure 2(a).
- A DC regulated power supply (Electro-Industries), a Digital Multi Meter (DMM - GW Instek), connecting wires and four coins (a Penny, Nickel, Dime and Quarter) were used for this study, shown in Figure 2(b).
- The power supply is used to apply a DC voltage across the coins and the current flowing through the coins were measured using DMM.
- The voltage across the coins was varied and respective current was recorded. The average resistance for each data was then calculated using Ohm's Law. A graph between voltage and current is plotted for all coins to find the value of resistance from the curve fitting.
- Then the resistivity and the conductivity of each coins were calculated using physical equations learned in the class.
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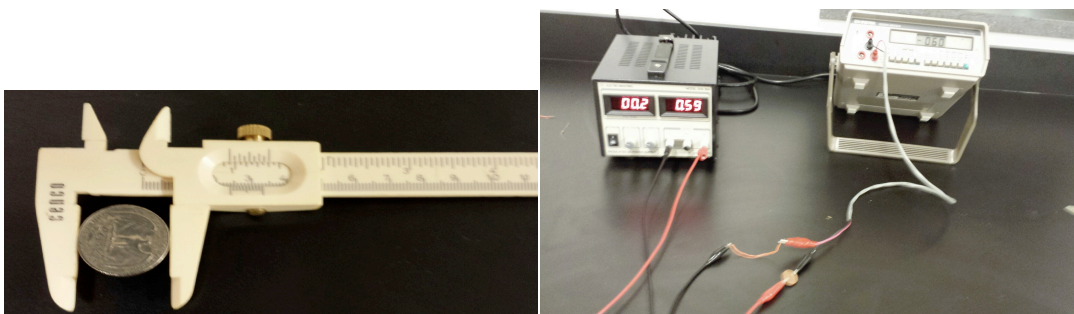


Figure 2: (a) measurement of a coin with Vernier Calipers, (b) Circuit connection.

EQUATIONS

Following equations were used during this project. Each symbol in these equations has their original meaning as given in any typical Physics textbook.

$$R = V/I$$

$$\rho = R \frac{A}{\ell},$$

$$\sigma = \frac{1}{\rho}.$$

$$\rho = \frac{E}{J},$$

$$E = V/d$$

$$J = \sigma.E$$

RESULTS

The dimension of each coin was recorded i.e. thickness and diameter with Vernier Calipers and found to be consistent with the dimensions given by "US Coin Specifications" ⁵. These coins are made up of alloys with two different metals. The metal content in each coin and its dimensions can be seen in the table 1.

TABLE 1: Coin Specifications

Coin	Penny	Nickel	Dime	Quarter
Metal %	2.5%Cu-Zn	25% Ni-Cu	8.3% Ni-Cu	8.3% Ni-Cu
D (cm)	1.905	2.121	1.791	2.426
t (mm)	1.52	1.95	1.35	1.75

Each coin was connected to power supply and DMM with connecting wires and current was recorded for a given voltage across the coin. A voltage and current graph is plotted for Nickel and shown below in Figure 3. It can be seen that the Nickel follows Ohm's Law. From the slope of the graph the resistance of the coin can be calculated.

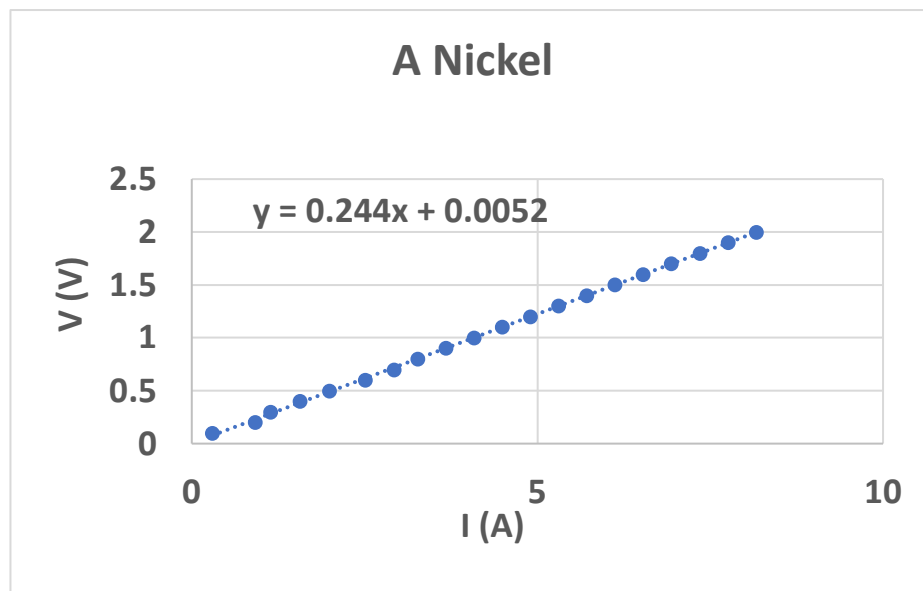


Figure 3: A typical voltage Vs current graph following Ohm's law.

A comparative current versus voltage graph was plotted for all four coins to see clear differences between slopes of all four coins and can be seen in Figure 4. The data follows Ohm's law and show a linear trend of variation for all four coins. The Quarter has the least slope and Penny has highest slope according to the results.

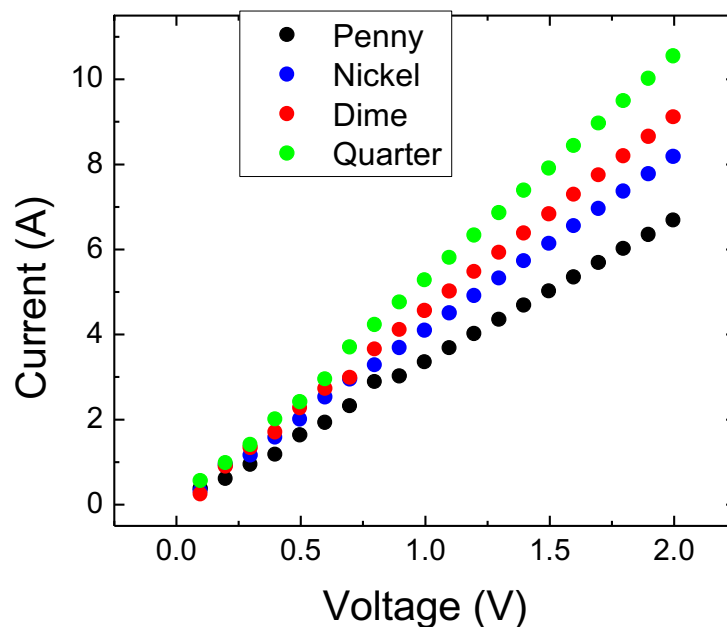


Figure 4: A comparative current vs voltage plot for all four coins.

The resistance, resistivity, conductivity, electric field within coin, and current density were calculated for all coins, can be seen in the table 2.

TABLE 2: Data for resistance, resistivity, conductivity, electric field and current density

Coins	R(Ω)	ρ (Ωm)* 10^{-3}	σ (S/m)* 10^3	E(V/m)	J (A/m ²)* 10^3
Penny	0.305	1.530	0.654	26.738	17.478
Nickel	0.244	1.643	0.608	23.256	14.151
Dime	0.230	1.012	0.988	28.736	28.394
Quarter	0.194	1.280	0.781	21.008	16.408

The resistance decreases from Penny to Quarter as can be seen in the table 2. It is consistent according the percent of material present in the form of alloy in each coin. The resistivity is found minimum for Dime because of its slimmest dimension. The conductivity and the current density is found maximum for Dime for the same reason of minimum dimension whereas the conductivity and current density are found minimum for Nickel because of its type of alloy and metal distribution. Figures 5 shows resistivity and Figure 6 shows conductivity of four coins.

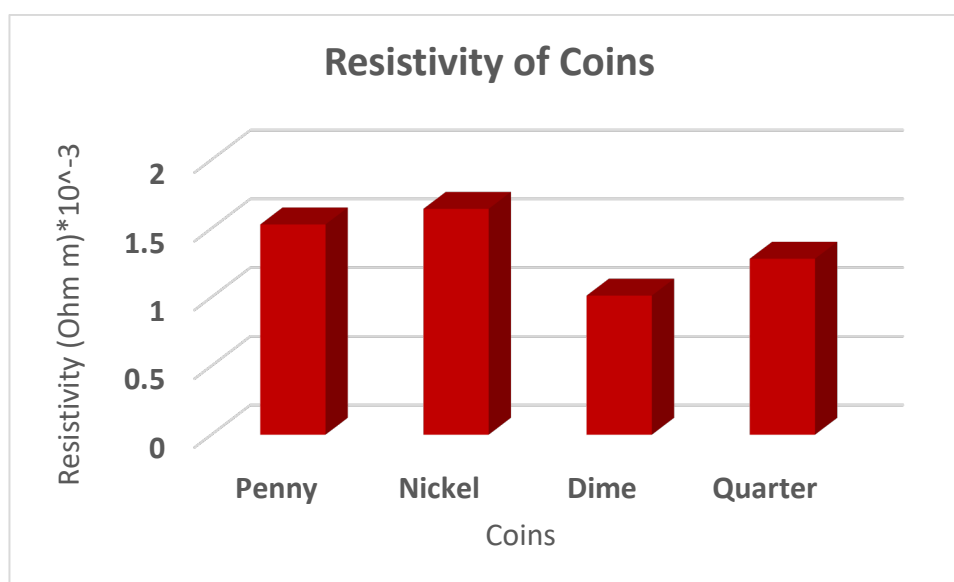


Figure 5: Resistivity of all four coins

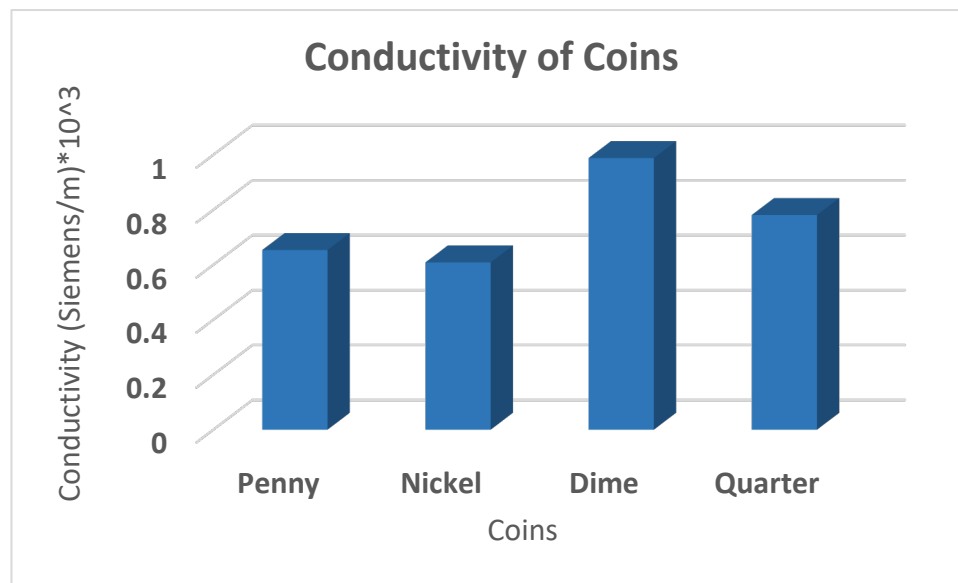


Figure 6: Conductivity of all four coins

DISCUSSION AND CONCLUSION

Within given voltage and experimental environment of Physics lab, all four real world coins follow Ohm's Law and showed significant results for resistance, resistivity, conductivity, current density. According to the percent of metal present in the form of alloy of each coin, Penny has highest resistance and the Quarter has lowest resistance. Resistivity is found minimum for Dime and conductivity & current density are maximum for Dime, because of its smallest size. Whereas, the Nickle has minimum conductivity and current density because of percent of material content in it.

This project showed a successful application of IPBTL teaching model and provided an interactive way of exploring Ohm's law related to real world applications within classroom of Physics course. Theories and equations used in this project helped students to understand their meaning not only theoretically but experimentally relating with real world applications. The results of four coins followed Ohm's law and showed significant values following metal contents percent in each coin and support the validity of Ohm's Law. This project helped students to understand the concept of resistance, resistivity and conductivity following Ohm's law in a practical way related to the real- world applications. The students in that class were mainly electricians and liked to learn Physics in that way.

OUTCOMES OF IPBTL MODEL

The course grades were compared for pretest and posttest and later compared for all three exams. The Figures 7 can be seen below those show the difference between course grade between pretest and posttest where grades were found higher in posttest after project and showed that students gained knowledge given by the project.

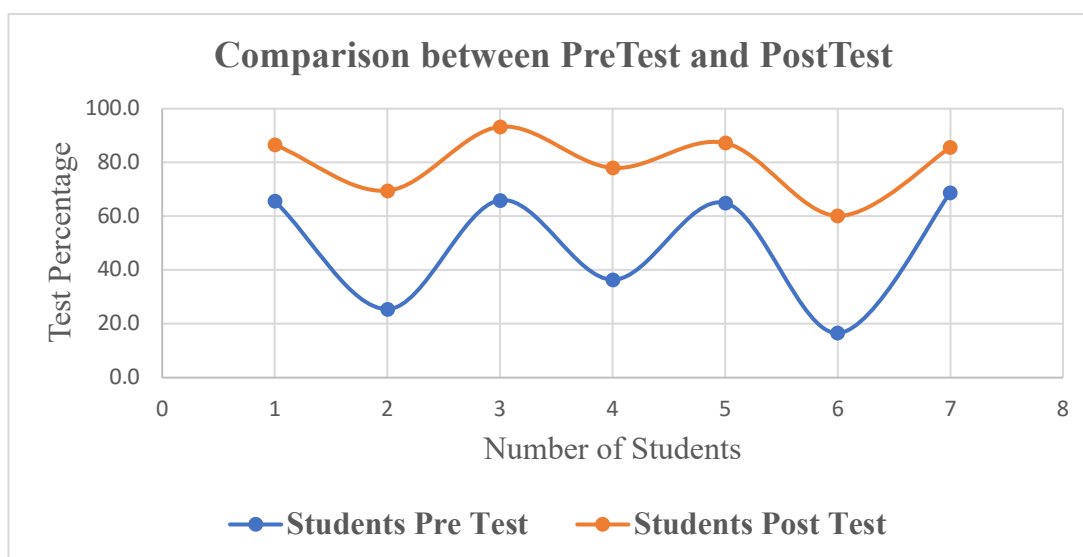
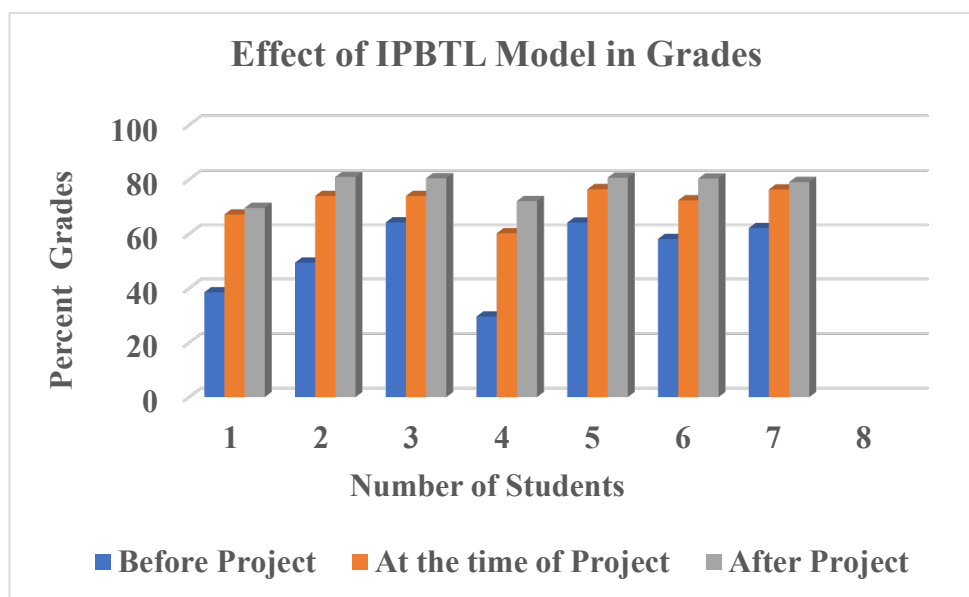


Figure 7: Comparison between pretest and posttest results of IPBTL teaching model in a Physics course.

Whereas Figure 8 shows the comparison between three exam grades and it can be seen clearly how course grades moved up and up by 2nd and 3rd exam. At the end of the course, students gave good feedback saying that they never liked Physics or never studied Physics with interest but now they loved Physics and want to do much more after this course if they can do.



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