A Woman in Engineering - Increasing Macao Students' Interest in Science and Technology

Sut-Ian Ho[2,3], Chi-Seng Lam[1,2], Man-Chung Wong[1,2]
1 - *State Key Laboratory of Analog and Mixed-Signal VLSI, University of Macau, Macao, China*
2 - *Department of Electrical and Computer Engineering, Faculty of Science and Technology, University of Macau, Macao, China*
3 - *Telecommunication Gallery, Macao, China*
E-mail: cslam@umac.mo or C.S.Lam@ieee.org

***Abstract*—To support and popularize Science and Technology (ST) to the Macao students and to train their interest are important. Since there were less than 7% of the higher educational students majored in ST in 2013. Therefore, the author, who is a guide of a telecommunication gallery in Macao, also has the duty to increase students' interest in ST. For this purpose, some science workshops, courses and demonstrations are designed by the author which are based on the internet information. In this paper, a do it yourself (DIY) battery workshop, a DIY simple electronic piano course and an electromagnetic demonstration are introduced with the examples to show how these programs are designed to train the student visitors' interest in ST. With the designs, science concepts and knowledge from books are presented in practical ways with real life examples for stimulating the students' creativities and initiatives of doing science experiments.**

Keywords—Science Workshop, Science Course, Science Demonstration, DIY Battery, Voltaic Pile, IC555 Piano, Paper Speak, Wireless Power System, Levitated Decoration

I. INTRODUCTION

In the Yearbook of Statistics of Macao S.A.R., it shows that there are more than 600,000 populations in Macao in 2013, and among these populations there are 27,776 enrolled students, see Table I [1]. In Table I, it shows the proportions of the study programs that enrolled by the Macao students in 2013, and it also can clearly show that there are about 6.53% students studied in Science and Technology (ST) such as: Computing (3.57%), Engineering (1.90%) and Architecture (1.06%). The proportion of studying ST among all study programs is very less, since many people in Macao mainly focus on business, economy and tourism; so the development of Science and Technology is not quite popular and thus there are less students studying the Science and Technology in Macao. Therefore, in order to increase the young students' interest in and popularize Science and Technology in Macao has been an important issue to many schools and educational organizations. Similar as museums in *21st* century, they are no longer places to display exhibitions only; thus improving the related exhibit knowledge to the public has also become a mission of those museums, especially for the young generation like students.

The author works as a guide in a telecommunication gallery in Macao, who also has the responsibility to popularize the information of Science and Technology to students. At the moment, the main service targets are primary and secondary school students. Besides the regular duty of guiding the visitors, designing programs and activities for schools and students to increase their interest in Science and Technology are also parts of the telecommunication guide's works. Therefore, the author has designed programs of some science workshops, courses and demonstrations for the primary and secondary students. These programs must be different from the conventional teaching method in schools, and should not only focus on books, formulas and complicated theories; instead, real experiments are designed to explain scientific phenomenon and basic principles. All the programs are not just designed for certain level students. For the students with different levels, we would give them different and suitable information. For example, the primary students are introduced the applications instead of talking about the theories, as they would easily memorize some scientific terms and experimental phenomena. The junior students, who may have some basic knowledge, would be given the information that matches their school teaching. The senior students will be additionally introduced about the experiments with theories. Moreover, in order to perform the word of "Telecommunication" and encourage students to make good use of internet resources to find information, most of the programs are developed based on the internet information.

Table I. Enrolled Students of Higher Education in 2013 [1]

Study Program	Students	Percentage
Teacher training and education	1,030	3.71%
Arts	848	3.05%
Humanities	2,262	8.14%
Social and behavioral science	1,212	4.36%
Journalism and information	1,442	5.19%
Business and administration	9,941	35.79%
Law	1,401	5.04%
Social services	494	1.78%
Personal services	5,778	20.80%
Health	1,254	4.51%
Computing	992	3.57%
Engineering and engineering trades	528	1.90%
Architecture and building	294	1.06%
Others	300	1.08%
Total	27,776	100.00%

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In this paper, the author would introduce the design of these programs for attracting students' interest in ST. A do it yourself (DIY) battery workshop, a DIY simple electronic piano course and an electromagnetic demonstration that designed by the author are used as examples to explain how these programs related to the ST that students can learn. In Section II, the chosen workshop of a DIY battery will be introduced. In Section III, the chosen design course of a simple electronic piano will be discussed, while Section IV is talking about the production of the electromagnetic demonstration. Finally, Section V will draw the conclusion.

II. Science Workshops

In addition to the conventional visitor guiding in the gallery, a number of science workshops are developed for increasing the interactivity between the museum and the students, and for improving students' handmade ability and their initiative in doing experiments. These workshops are mainly designed with some common or recycle materials in life, and performed with some simple operation processes; through this way, it can give students some surprise and fun during experiments. Moreover, with additional simple and related information, it can supplement students' knowledge which learnt from their textbooks.

As an example, **"**DIY Battery Workshop**"** is one of the science workshops. This workshop is to introduce the basic historical story and development of Battery, and also let the students redo the experiment of the first battery - the Voltaic Pile in the early 19th Century [2], as well as with some simple physical and chemical knowledge. In the workshop, the Voltaic Pile is simply made of some Macao coins, salt-water soaked paper napkin and aluminum foil sequentially. A Voltaic consists of many Voltaic elements; each Voltaic element is constructed in the order of from the top to the bottom as a piece of foil, a salt water-soaked paper napkin and a coin, see Fig. 1. By the way some related physical and chemical information can be provided to students.

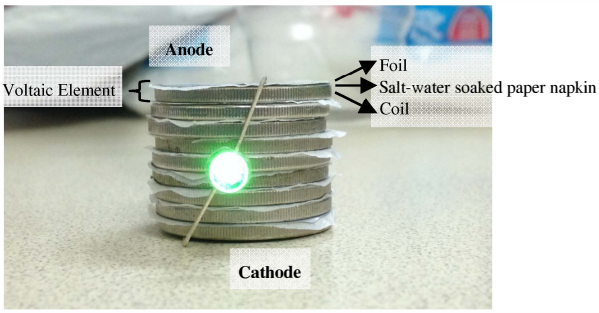


Fig. 1 A DIY Voltaic Pile with 10 voltaic elements is tested by a Green LED.

In the physical aspect, the Voltaic Pile, which consists of 10 series voltaic elements with each 0.45~0.7V, has a total at least of 4.5V. Students would learn how to use the voltmeter to measure the voltage. Also the Voltaic Pile would then be tested by a low operation voltage rating light emitting diode (LED), such as 1.8V to 2.5V which would give a better result, also see Fig. 1. As the LED is connected to the Voltaic Pile, the Pile voltage would then drop to the LED operation voltage level due the current required by the LED is higher that the Voltaic Pile generated.

In the chemical aspect, this Voltaic Pile, which is also called the aluminum-air battery, generates electricity due to the oxidation reaction with the aluminum at the anode in (1) and the reduction with the oxygen in the electrolyte at the cathode in (2) [3] [4]:

$$Al + 3OH^- \rightarrow Al(OH)_3 + 3e^- \quad (1)$$

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^- \quad (2)$$

The electrolyte of the Voltaic Pile is actually the salt-water in the soaked paper napkin for the Oxidation Reduction Reactions take place. As Macao coins that used in the experiment contain about 65% to 75% of Copper (Cu) [5] and the aluminum foil is mainly Aluminum (Al), which is not considered the aluminum compound problem due to the oxidation in air [6] for simplification. And according to the Reactivity Series of Metals [7], it shows that the aluminum is more active than the copper. So the aluminum foil works as the anode, in which the oxidation reaction happens to generate electrons, and the electrons flow to the external load which is the LED used for testing the battery here. Whereas the Macao coin is used to conduct the electron flow from the external load to the oxygen in the electrolyte, where works as the cathode for reduction reaction. Then the negative ions of the salt water bring the electrons back to the aluminum foil to compensate the electron loss of the anode and complete the circuit path [4].

Surprise is expected to give to the students with these simple objects in their daily life that can be used to generate electricity, as they can use the simple items or recycled materials to create unexpected science works in such a simple way. This also gives the students an opportunity to experiment some simple theories that they have learnt from their textbooks, and let them use both of their hands and brains at the same time.

III. Science Courses

In order to give students more opportunity of practicing the electronic science and let them experience how to apply the textbook knowledge in the real life, as well as to meet the development of science and technology education in schools, some short term science courses with 4 lectures about totally 10 hours are designed for the students. So schools can organize the students who are interested in the science class and arrange them to join the courses in their interest class time, after school or during weekends. Then the students can learn how to convert the text and graphics from their textbooks and applied them to their life. In this section, the workshop of **"**DIY Simple Electrical Piano**"** is chosen as an example to explain the course design.

"DIY Simple Electrical Piano**"** is one of the 4-lecture science courses designed by the author. This course is to teach students how to design, and make a simple electrical piano

using an integrated circuit (IC) 555 and to generate different pitches with different frequencies. In this 4-lecture course, students would learn the knowledge about the sound production and frequencies of music pitch, the skill of reading IC datasheet, how to use the IC 555 and design the circuit printed board (PCB) layout, as well as the way to solder circuit board and package the product and so on. The major parts of the course is to let students know how to use IC 555 to generate the required frequency pulses by calculating the desired electronic component values and to connecting them into the circuit. In this course, students will select a group of pitches from a given table of pitch frequency as shown in Table II [8], and use the IC 555 as an oscillator to generate the related frequency pulses based on the circuit connection as shown in Fig. 2. In Fig. 2, the capacitor (C_3) and the resisters of (R_1) and (R_x) are the output frequency control parameters, where **"*x*"** denotes the music pitches of *do*, *re*, *me*, *fa*, *so*, *la*, *se*. However, in order to simply the design, the values of C_3 and R_1 are fixed, and R_x is chosen to be the only output frequency control. Therefore, according to the required output frequency (f), R_x can be designed through (3) [9].

Table II. Pitch Frequency of Music for Different Octaves

Frequency (f) in Hz								
Octave / Pitch	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Do	33	65	131	262	523	1047	2093	4186
Re	37	73	147	294	587	1175	2349	4699
Me	41	82	165	330	659	1319	2637	5274
Fa	44	87	175	349	698	1397	3794	5588
So	49	98	196	392	784	1568	3136	6272
La	55	110	220	440	880	1760	3520	7040
Se	62	123	247	494	988	1976	3951	7902

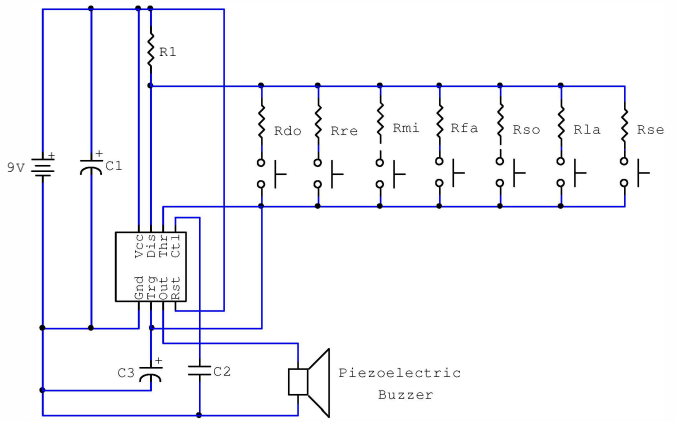


Fig. 2 The circuit diagram of the IC 555 electrical piano.

$$R_x = \frac{1}{2}\left(\frac{1.44}{C_3 * f} - R_1\right) \tag{3}$$

After the students figured out the frequency control resistor (R_x) value, they would learn to use bread boards to connect and test the circuit. Using bread boards can give a concept to the students that how the circuit would be and have a rough outlay of how to place the electronics on the PCB. Then the students are required to solder the circuit by themselves. Meanwhile, the students also need to make a simple speaker by using a piezoelectric buzzer and a paper or plastic cup; and they can also choose and test other materials to make the speaker body to see which kind of materials would obtain better results.

The science courses are mainly used to teach students a method of implementing knowledge and theories. It stimulates students' creativity and guides them to make a concept to be a completed product from searching information, designing, planning process, producing and packaging. Students are encouraged to develop their own science projects.

IV. Science Demonstrations

As students may interest in certain sections of the exhibit gallery, in order to better meet their needs smoothly, different science demonstrations are developed for the students. So the schools can select their favorite ST themes and the students can learn what they are mostly interested in. Each science demonstration lasts about 40 minutes, and it mainly shows the science phenomena, implementations and applications of some science principles by using daily life examples. Therefore, in this section, design examples of a paper speaker, a wireless power system and a levitated decoration that are made by the author for explaining the "Magnetic Effect of Electric Current", "Magnetic Induction", and the "Applications of Electromagnetism" in the electromagnetism science demonstration will be introduced.

A. *Paper Speaker*

In this electromagnetic demonstration, the paper speaker is used to explain the "Magnetic Effect of Electric Current" phenomenon and it is made of a strong magnet, a piece of paper and an aluminum foil trip, which is wrap as a coil on the paper, as shown in Fig. 3. According to the "Magnetic Effect of Electric Current", when an electrical sound source, such as MP3, computer or mobile phone, is connected to the speaker, the electrical signal flows through the aluminum coil, the coil will produce a varying magnetic field. If a magnet is placed close to the coil, the magnetic fields from the coil and the magnet will continuously attract and repel each other, cause the paper to vibrate and produce the sound [10].

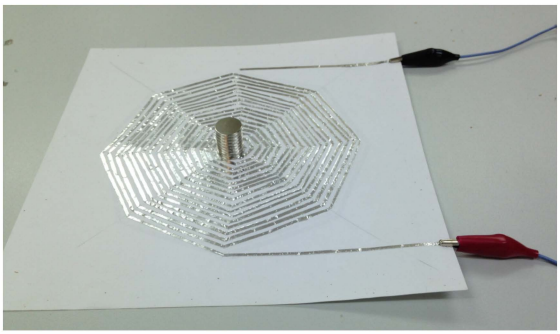


Fig. 3 A paper speaker with a foil coil attached on the paper that is activated by a strong magnet.

B. *Wireless Power System*

Wireless power system is another interesting experiment to explain the "Magnetic Induction" theory to students. The wireless power system has two coils. One is the source coil which is connected to an oscillator circuit for producing the varying magnetic field, and the other receiver coil is connected to a LED with a DC converter which is to convert the alternative current to direct current. Referred to the "Magnetic Induction" theory, when the second coil is placed close to the source coil, it would sense the varying magnetic filter and generate induced current to light up the LED, as shown in Fig. 4 [11].

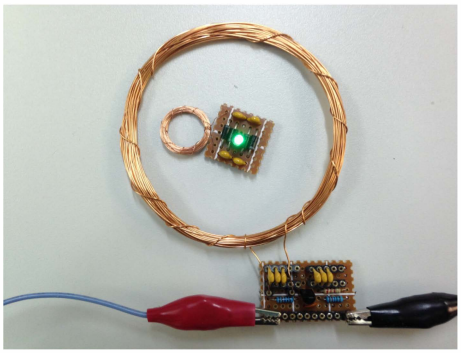
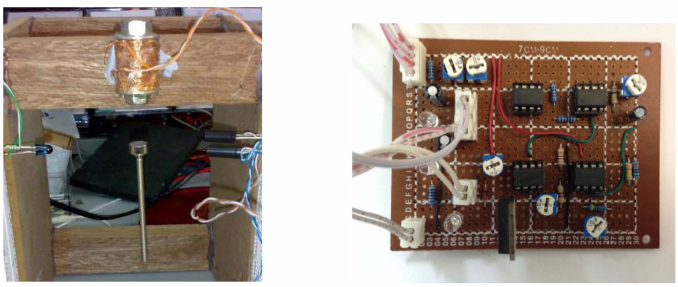


Fig. 4 The wireless power system shows an On-state LED connected to a small receiver coil powered by a big source coil wirelessly.

C. *Levitated Decoration*

This levitated decoration displays one of the "Applications of Electromagnetism" and how to control a small object with an attached magnet to float. The levitated decoration contains two parts: the floating part with detection and the control part. The floating and detection part is made by an electromagnet and a magnet with a small object, a sensor pair of an infra red (IR) transmitting diode and a light receiving photo diode; whereas the control part has other components, as shown in Fig. 5 [12]. Simply, when the sensor detects the suspending object drops downward which means the photo diode detects the infra red, it will drive the electromagnet to attract the object upwards. And when the sensor detects the suspending object which means the photo diode senses nothing as the infra red is blocked by the object, it will stop driving the electromagnet and let the object drops again. Therefore, the suspending object would fall down and rise up continuously by the repeating process, and it leads to the floating phenomenon of the object.



(a) (b)

Fig. 5 The prototype of the levitation device: (a) the floating and detection part and a floating screw with a magnet attached and (b) the control circuit part.

The demonstrations are highly interactive with students, as they are required to join the experiments. As the demonstrations are developed based on the daily life examples, it tells students clearly that if they look around carefully, there are so many things that are related to science.

V. Conclusion

In order to increase students' interest in Science and Technology (ST), science programs such as workshops, courses and demonstrations are designed by the author for the students. New ideas related to daily life are always searched from internets. The designed programs not only carry out the scientific theories, but also can increase the students' interest and improve their understanding in ST topics. Therefore, it can give students a concept that they are possible to create the ST product by themselves, thus it can inspire students' creativity and encourage them to experience with their ideas.

VI. Acknowledgments

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