Paper ID #32246

Chemistry and Transportation Engineering Experiment-Centric Pedagogy with Hands-on Labs

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Mrs. Ida Mougang Yanou N, Morgan State University

• University of Yaoundé I Cameroon: BS Degree in Chemistry, 2009 • University of Yaoundé I Cameroon: MS Degree in Organic Chemistry, 2011 • University of Dschang Cameroon: MS Degree in Environmental Impact Assessment, 2015. • Responsible Conduct of Research Course Certificate (Social and Behavioral Research) at CITI program, 2019. • Morgan State University USA: Doctorate student in Environmental Engineering enrolled since Spring 2019

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EDUCATION/TRAINING

University of Turku (Finland) Ph.D. 2007 Bioorganic Chemistry University of Maryland Baltimore County (USA) Post-doc 10/2007-08/2013 Organic, Analytical Chemistry and Toxicology

POSITIONS

10/2007 – 08/2013 Research Associate, Department of Chemistry, UMBC, MD 08/2013 - 12/2013 Adjunct, Dept. Chemistry, McDaniel College, Westminster, MD 08/2013 - 12/2014 Adjunct, Dept. Chemistry, Baltimore City Community College, MD 12/2014 - 06/2014 Adjunct, Dept. Biochemistry, Coppin State University, Baltimore, MD 08/2014 - 05/2018 Adjunct, Dept. Chemistry, Community College of Baltimore County, MD 01/2014 - Ongoing Lecturer, Dept. Chemistry, Morgan State University, MD

Other Experience and Professional Memberships Journals Reviewer: 2006 - Nucleosides Nucleotides & Nucleic Acids 2010 - Royal Society of Chemistry 2010 - Current Chemical Biology 2010 - Journal of Encapsulation and Adsorption Sciences

Memberships 2007 - IS3NA (The International Society for Nucleosides Nucleotides & Nucleic Acids) 2009 - 2012 ASTS (African Society for Toxicological Sciences) 2009 - 2011 NOBCChE (National Organization for the Professional Advancement of Black Chemists and Chemical Engineers) 2012 - 2014 ACS (American Chemical Society), Organic Chemistry and Toxicology Divisions 2013 - 2014 Policy council of head Start (YMCA), Towson, MD

Contribution to Science

1 - My previous research has been to understand the chemistry of the key intermediates that mediate the biological effects of mutagenic and carcinogenic nitrosamines. Nitrosamines are a large class of compounds

to which there is human exposure through endogenous formation and environmental sources. They are found in groundwater, foods, personal care products, and tobacco products and are encountered in a number of industrial environs, in particular in rubber manufacturing and curing facilities, metal and leather working concerns. They tend to target the oxygen atoms of DNA by means of adducts they form and cause replicative polymerases to mis-insert opposite these lesions leading to mutation. My work involves modified phosphoramidites synthesis and their characterizations. I have developed new methods for various nucleoside crosslink standards synthesis, their characterizations and derivatizations. I established new route for 13C labeled precursors in cross-link mimic, and their introduction into oligonucleotides for NMR studies. I have supported chemistry process with methods for reaction monitoring regarding purity/yield and analytical studies. We have explored sequence-specific recognition of nitroso derived adducts of minor groove of DNA and determined the effect of various factors on crosslink formation. Through our collaborations, we have studied the mutations spectrum in human fibroblasts which have attracted some research groups.

[1] Koissi N., Fishbein C.J.: (2013) Trapping of a Cross-link formed by a major purine adduct of a metabolite of the carcinogen N-Nitrosomorpholine by Inorganic and biological reductants. Chem. Res. Toxicol. 26, 732

[2] Koissi N., Shah N., Ginevan B., Eck W.D., Roebuck B.D., Fishbein C.J., (2012) A lactone metabolite common to the carcinogens dioxane, diethylene glycol and N-nitrosomorpholine: aqueous chemistry and failure to detect liver cancer induction or promotion in the F344 rat. Chem. Res. Toxicol. 25, 1022

2 - My major contributions have in the area DNA base modifications of oligonucleotide conjugates. The subject is of general importance, since accumulation of DNA base moieties induced by environmental contaminant, food additives or oxidizing atmosphere constitute an increased risk of cancer. I developed several methods useful for syntheses of such structurally modified constituents of DNA and studies of their properties and mechanisms of formation. In particular, his studies has advanced the understanding of the ability for 1,3-dicarbonyl compounds and their congeners to form cyclic adducts of nucleobases. Such compounds are produced intracellularly as end products of the catabolism of peroxidated fatty acids of cell membranes. Cell membrane peroxidation, in turn, is a consequence of oxidative stress caused by increased level of ozone and peroxidated organic acids in urbanized regions. [1] Koissi N., Lönnberg H.: (2007) Synthesis of modified nucleosides for incorporation of formyletheno and carboxyetheno adducts of adenine nucleosides into oligonucleotides. Nucleosides, Nucleotides & Nucleic Acids 26, 1203

[2] Ruohola A-M., Koissi N., Andersson S, Lepistö I., Neuvonen K., Mikkola S., Lönnberg H.: (2004) Reaction of 9-substituted guanines with bromomalonaldehyde in aqueous solution predominantly yield glyoxal derived adducts. Org. Biomol. Chem. 2, 1943

[3] Neuvonen K., Koissi N., Lönnberg H.: (2002) Condensation of triformylmethane with adenosine: novel cyclic adducts derived from 1,3-dicarbonyl compounds. J. Chem. Soc., Perkin Trans. 2. 173

[4] Mikkola S., Koissi N., Ketomäki K., Rauvala S., Neuvonen K., Lönnberg H.: (2000) Reactions of adenosine with bromo- and chloromalonaldehydes in aqueous solution: kinetics and mechanism. Eur. J. Org. Chem. 12, 2315

3 - My understanding of bioorganic chemistry has given me the opportunity to teach biochemistry even as chemistry major. Through my research, I have developed multi-step synthesis protocol for halocarbonyls, halodicarbonyls, tricarbonyls, and nitroso compounds. Some of these synthesis have found their route into industry and are used for big scale production. www.syntechem.com/prod/STP280277/ www.sigmaaldrich.com/catalog/papers/22458541 datasheets.scbt.com/sc-52666.pdf

Dr. Celeste Chavis P.E., Morgan State University

Celeste Chavis is an Associate Professor in the Department of Transportation & Urban Infrastructure Studies in the School of Engineering at Morgan State University in Baltimore, MD. Dr. Chavis is a registered professional engineer in the State of Maryland. Her research focuses on transportation operations, safety, and performance metrics for multimodal transportation systems through an equity lens. Dr. Chavis specialized in instructional technology, STEM education, and ABET accreditation.

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Dr. Oludare Adegbola Owolabi P.E., Morgan State University
Dr. Jumoke 'Kemi' Ladeji-Osias, Morgan State University

Dr. J. 'Kemi Ladeji-Osias is Professor and Associate Dean for Undergraduate Studies in the School of Engineering at Morgan State University in Baltimore. Dr. Ladeji-Osias earned a B.S. in electrical engineering from the University of Maryland, College Park and a joint Ph.D. in biomedical engineering from Rutgers University and UMDNJ. Dr. Ladeji-Osias' involvement in engineering curricular innovations includes adapting portable laboratory instrumentation into experiments from multiple STEM disciplines. She enjoys observing the intellectual and professional growth in students as they prepare for engineering careers.

Chemistry and Transportation Engineering Experiment-Centric Pedagogy with Hands-on Labs

Abstract

This project developed small, portable sensor-based experiments as an alternative to those conducted in a traditional laboratory setting. Experiment-centric pedagogy was used in this study and hands-on laboratory experiments were developed using USB-based measurement devices. Three experiments were developed for Chemistry namely pH meter, thermochemistry, and spectrophotometry. During pH settlement, the voltage was recorded, and the calibration curve drawn using standard buffers 4, 7, and 10. Furthermore, thermochemistry results were performed and validated using a digital thermometer. The correlation coefficient R^2 curves have been found to yield good results for both experiments. The Department of Transportation worked on three experiments which include a vehicle counter, decibel meter, and a soil moisture meter. Data was recorded from each setup. Since the sensors provided results as voltages, a transfer function equation was used to convert the reading to the required unit of expression to validate the results from the USB device.

These experiments were developed by pairing a graduate student in electrical engineering with a student in another discipline during a 10-week summer workshop. Student trainees underwent different training sessions that comprise of developing and testing instruments for measurement, attending the ASEE virtual conference, and research workshops. Students also read and summarized articles on the use of experimental pedagogy to motivate students.

This study is designed to improve outcomes for students in the chemistry and transportation departments using laboratory activities.

Keyword: Chemistry, Transportation, Sensor, Active Learning, ADALM Board, and Experiment Centric Pedagogy

Introduction

Laboratory experiments are an important component of the educational experience for engineering students. Structured laboratory experiences can make engineering concepts come to life, giving students a real-world confirmation of the theory and ideas [1], [2]. Conversely, the effectiveness of hands-on learning can be reduced if there are inadequate levels of student engagement and reflection [3], [4]. There are different learning settings in which a student can engage such as a laboratory, online classes, and through daily activities [5], [6], [7]. This study shows how traditional labs can be transformed into hands-on labs by integrating USB-based personal instrumentation used in electrical engineering. This approach is based on experimental centric pedagogy which integrates problem-based activities and constructivist-based instruction using personal instrumentation that is designed to replace larger laboratory equipment [8]. For this project, the electrical engineering team supported each experiment by assisting with selection of the sensors, building the circuits to connect the sensor to the personal instruments and setup of the hands-on lab [8]. This paper will describe the approach to select experiments, provide details on the experiments developed for Chemistry and Transportation Engineering and provide recommendations for future activities. The chemistry experiments are designed for introductory courses while the transportation experiments are for advanced courses and include a study of the difference in the level of noise with comparison of a major highway [9] [10]. There are potential applications of these experiments, described below, to other courses.

Potentiometry: In conjunction with the basic hands-on lab activities carried out during summer research, we were able to develop a potentiometry experiment. The chemistry laboratory experiments include introducing a modern, hands-on learning pedagogy to replace existing laboratory experiments in thermochemistry, pH testing, and temperature transfer lab. This is designed to aid students in identifying the pH level of solutions by testing common household substances. Student will understand how pH level determines type of compound or solutions they are (acid, neutral or basic) and how they react with other substances called indicators.

Thermochemistry: In this temperature experiment, we will be introducing the theoretical and practical demonstrations through hands-on lab exercises to chemistry students. In order to incorporate this temperature experiment, an analog temperature sensor connects directly to an ADALM 1000 board which records the data. Furthermore, a temperature sensor (digital temperature sensor) is used to measure temperature change with standard prepare buffers samples from the chemistry lab. The objectives of the thermochemistry experiment are to measure the temperature changes of solutions with buffer samples provided in this laboratory and plot temperature change. In addition, this experiment aims to develop an understanding of thermodynamic concepts, such as temperature, enthalpy, heat and heat capacity, and their relationships.

Decibel meter: The objective of this experiment is for transportation students to know the essentials of sound theory, measure sound and illustrate the results. It requires a noise sensor (analog sound sensor) with the ADALM1000 to obtain measurements converted to decibels (dB). In another lab exercise, the instructors will demonstrate to the students in the class through hands-on lab, the quietest audible sound (perceived near total silence) using a decibel meter and increasingly louder sound**.** The students will then measure noise due to transportation facilities of various sizes, both indoors and outdoors. Students will be able to relate Federal regulation and control on noise levels to the location of noise-sensitive land uses. The students will learn the various sources of transportation noises and the factors affecting transportation noise propagation. This a new experiment in which students check the decibel levels of neighborhoods, highways, and soil moisture content.

Soil Moisture: The soil moisture content experiment is designed to determine the water content of concrete sand and to better understand the the measurement scale of soil moisture. It is essential to ascertain soil moisture content to better understand soil characteristics. Water content or moisture content is the amount of water stored in a sample, such as, soil specimen. In this method, the amount of water in a volume of soil is estimated by measuring the amount of hydrogen it contains, expressed as a percentage. Samples are placed in a suitable glass jar, and recorded with ADALM 1000 data logger. A soil moisture sensor is utilized to measure the soil moisture content.

In the long term, this research study aims to increase the number of highly qualified and prepared African American engineers. In the United States, there are 107 HBCUs with more than 220,000 enrolled students, including our university. They currently represent around 3% of all higher education institutions in the United States and produce 27% of African American students with a bachelor's degree in the STEM field [11]. This research will mainly be of interest to academicians, researchers, and students interested in understanding the development of experiments with commonly available sensors.

Methodology

This study provides an overview of pilot research using engineering techniques and hands-on mobile devices, consisting of an input/output board. It is a hands-on laboratory experiment activity to replace the traditional laboratory experiments in the Chemistry and Transportation Departments by collating data through electronic measurements (oscilloscope, voltmeter, and other) from sensors attached to the board. Analog Device Active Learning Module (ADALM 1000 and ADALM 2000) are instruments with an embedded system that are easy to use for students in the hands-on lab at a comfortable position and are portable. The ADALM1000 module comprises essential tools like oscilloscopes, signal generator, voltmeter, and other valuable tools for the students to better understand STEM activities better and may be adopted by students at all levels in academia and from many backgrounds. There is an additional feature of these ADALM boards which needs application of a transfer function equation to convert voltage and frequency readings from the device into the required measurement unit. The Experiment Centric Pedagogy (ECP) uses this cheap, easily located, and compatible electronic instrument system that can be utilized in both lecture rooms and hands-on laboratories. The experiment research identified and developed instruments available for use in the fall semester of 2020 by the chemistry department and transportation engineering courses. The chemistry department's laboratory experiments include introducing a modern, hands-on learning pedagogy to replace existing laboratory experiments in thermochemistry, pH testing, and temperature change lab. The transportation engineering department experiment proposed new experiments in which students check the decibel levels and soil moisture content. Description of all hands-on laboratory experiment designed during summer 2020 activities. See in Table 1.

Chemistry Hands-on Experiments

Experiment 1 - pH meter (potentiometry): The chemistry hands-on experiments are initiated with the pH experiment (potentiometry). The objective of this laboratory experiment is to estimate the pH scale of an unknown solution (buffer) through the calibration curve. In this experiment, we will develop a calibration curve from standard pH buffers solutions (4, 7, and 10) and then use it to determine the potential scale of other solutions. This lab is currently taught in general chemistry lab courses, but this adaptation will allow student to participate in hands-on lab and carry out experiment outside the laboratory. The complete laboratory equipment consists of pH buffers solutions, the pH probe (Gravity Analog pH sensor) which is the sensor used to measure pH of different (buffer) solutions, and the ADALM2000 personal instrument. See in Figure 1.

Table 1: Summary of the hands-on lab experiment

Department	Experiment	Description
Chemistry	Potentiometry	pH meter experiment is used to determine different solutions and their pH levels.
	Thermochemistry	This is used to measure temperature change with standard buffers.
Transportation	Decibel Meter	This experiment is used to measure the decibel level of indoor and outdoor areas.
	Soil Moisture Meter	The experiment is used to measure the soil moisture content.

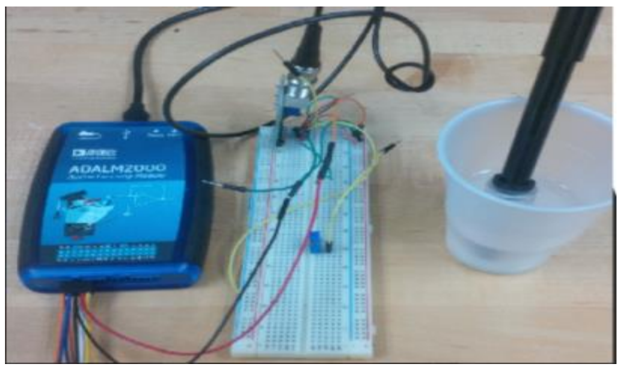

Figure 1: Experiment of pH sensor

The Analog pH Sensor Kit V2 [12] can be used measure the pH scale of the soil, liquids, and food, and others. This pH electrode probe has a single cylinder that allows connection to a pH probe meter, controller, or any pH device with a bipolar N connector access endpoint. The pH probe is an accurate device that can give almost instantaneous readings. The analog pH probe sensor is specifically ready configured to convert the buffer solutions from voltage reading into a pH scale. The onboard current or voltage regulator component operates at an advanced voltage supply of 3.3V to 5.5V, compatible with 5V to 3.3V main control boards. See in Figure 2.

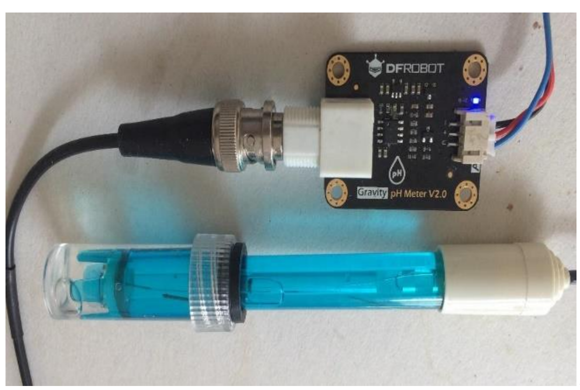

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Figure 2:pH sensor

Experiment 2 - Thermochemistry: The temperature experiment is built to ensure that students can distinguish different temperature changes of the buffer solutions during the hands-on research lab and compute the result. The digital temperature sensor (DS18B20) is an ideal experimental measuring device for the different chemical solutions or mixture of solutions used to evaluate temperature changes during the experiment (See in Figure 3). Thermochemistry experiments are comprised of the temperature sensor and ADALM 1000 to record voltages.

These are specifications of the DS18B20 Digital temperature sensor, which has 2.7V to 3.6V and a temperature range of 0-60 degrees. The sensor is an ideal measuring device for chemical solutions in school laboratories. The device can be use in the thermochemistry course with the ADALM 1000. See in Figure 3

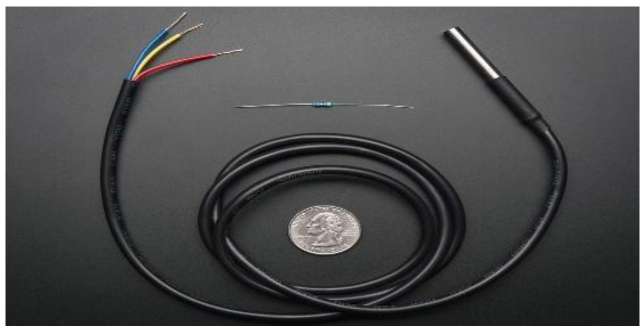

Figure 3: Sensors: Digital temperature sensor DS18B20

To effectively validate the result shown by the oscilloscope, we utilized a household digital thermometer. The aim of the thermochemistry experiment was to determine and record temperature change using ADALM 1000. The first step was to determine and record the temperature of water whereby three different water temperatures were measured using the ADALM 1000. This experiment was validated using the common household digital thermometer and DS18B20 digital temperature sensor. To calibrate this sensor, we setup samples of cold water, boiling water, and ice. See in Figure 4.

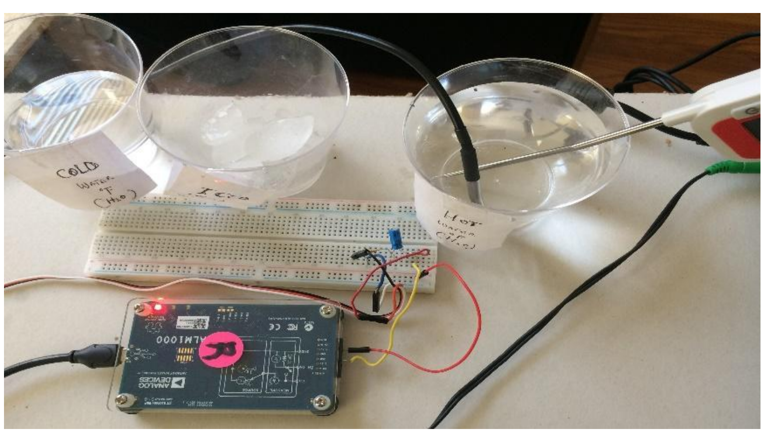

Figure 4: Thermochemistry experiment

Transportation Hands-on Experiments

The Transportation Engineering experiments used instruments to measure speed, vibration, sound, motion, soil moisture content and displacement.

Experiment 1 - Decibel Meter: A decibel meter can assess noise or sound levels by calculating sound pressure. These were referred to as a sound pressure level (SPL) meter, decibel (dB) counter, noise meter, and sound level meter using a microphone sound sensor. The sensor can be used to measure the proper sound level. The decibel level is obtaining from the voltmeter reading with the addition of the transfer function equation. See in Figure 6. Specifications of the analog sound sensor (Gravity Analog Sound Sensor DFR0034) include 3.3V to 5V user-supplied power and sensor size of 22 x 32mm (0.87 x 1.26 in). See in Figure 5.

In this experiment, the analog sound sensor (Gravity Analog Sound Sensor DFR0034) connects directly to the Analog Device Active Learning Module (ADALM 1000) board. The ADALM 1000 supplies five volts to the sensor`s power port with the ground (GND) port and channel port to read the data in voltage. See in Figure 6.

Figure 5: Gravity Analog Sound Sensor(DFR0034)

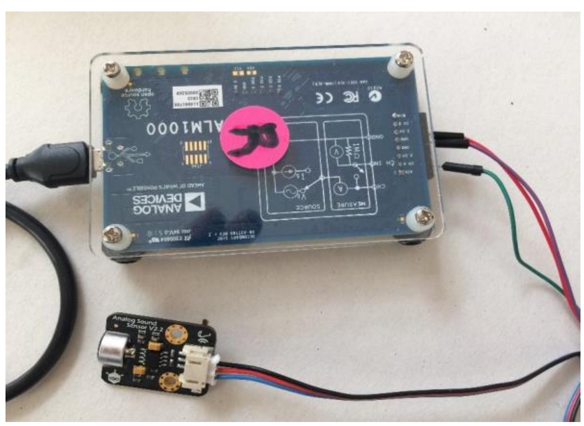

Figure 6: Experiment of sound meter

Experiment 2 - Soil moisture sensor: This multiple function sensor develops tools which can use in the hands-on lab with gravity soil moisture sensor. This sensor can be used to measure the soil moisture content and detect the soil sample. To determine the type of soil mixture, content and water hold by introduce the ADALM 1000(M1K). The soil moisture sensor has 3.3V to 5V user supplied power, with output voltage signal of 0 - 4.2 volt and current of 35mA. See in Figure 7. Data can be collected using ADALM 1000 (ALICE desktop) with transfer function. See in Figure 8.

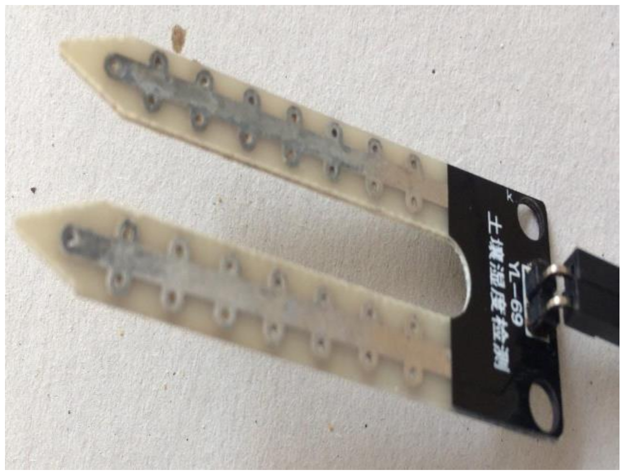

Figure 7: Soil moisture sensor

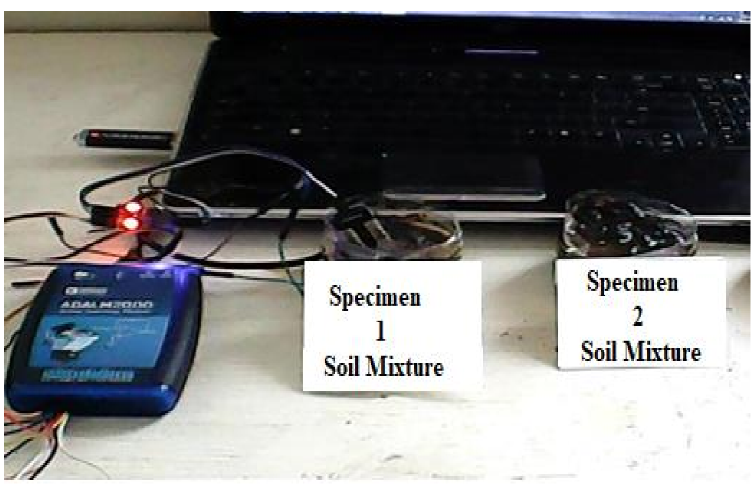

Figure 8: Experiment of soil moisture sensor with the circuit

The initial hands-on lab experiment using soil in residential areas. This soil had varying consistency due to the mixture conditions. Six lab prepared sample specimens of varying soil moisture content were used to validate the readings and calibrate the soil moisture sensor. See in Figure 9.

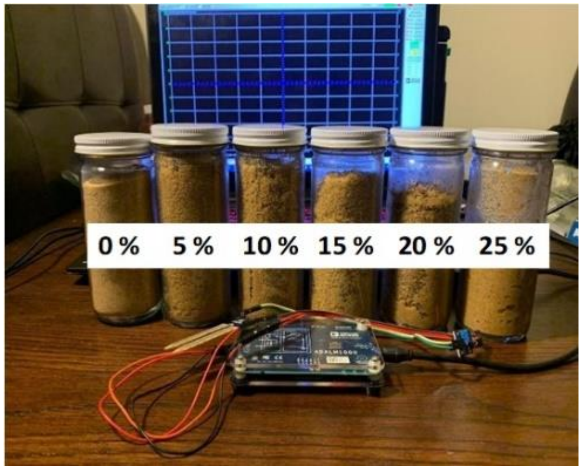

Figure 9: Concrete sand with moisture content for calibration of the sensor

This hands-on lab experiment was used to determine the moisture content of different soil samples. There were six specimens prepare from the laboratory with percentage , there are following samples used in the hands-on experiment activities which is 0 (zero) percent, 5 (five), 10 (ten) percent, 15 (fifteen), 20 (twenty), and 25 (twenty-five) percent. First the moisture sensor is calibrated before determining the soil moisture content and data readings. See in Figure 9.

Results

This is based on the preliminary results from four hands-on laboratory experiments completed for the Chemistry and Transportation department. During the ETA-STEM summer research potentiometry, thermochemistry, decibel meter, and soil moisture experiments were developed. The experimental centric pedagogy aspect for transportation department will be implemented in the Fall 2020 semester while the experiment for the chemistry department will be implemented in the Spring 2021 semester. The outcome will be reflected in a 2021 publication. The work is a based on continuing research from a previous ASEE conference paper titled "Initial impact of an experiment-centric teaching approach in several STEM disciplines" [12].

Chemistry Experiment Results

We used the oscilloscope software from the ADALM boards to log and save the data displayed on the software interface of the ADALM 1000 and ADALM 2000 in the form of voltage readings during the Chemistry department hands-on lab.

Results of Potentiometry Experiment: This experiment is set up with the pH sensor from the hands-on laboratory experiment research. The following results of the calibration set-up and compiled the collected data. See in Table 2 below. The calibration steps taking are typically performed before each measurement with a known pH scale buffer solution to ensure further measurement (See in Table 2). The correlation coefficient R^2 value has correlated to yield good results (R^2= 0.977), as described in Figure 2 below. The more R^2 is approaching 1, the better the calibration curve. See in Figure 10.

Table 2: Result of Potentiometry experiment

pH Buffer solutions	Voltage (V)
Buffer pH = 4	2.033
Buffer pH = 7	1.626
Buffer pH = 10	1.098

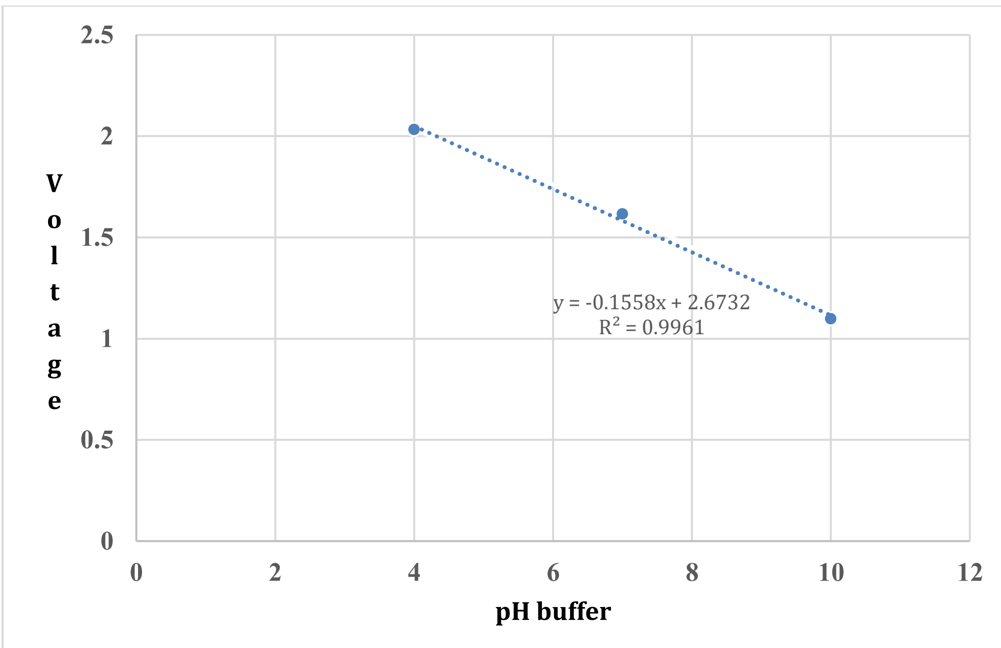

Figure 10: pH Calibration curve

Results of Thermochemistry Experiment: This experiment is performed using the temperature sensor to collate the data record and compiled. The study was conducted with three samples including cold icy, cold water, and boiling water. See in Table 3.

Table 3: Results of Thermochemistry Experiment

Temperature (^{0}c)	Voltage (mV)
0	0.1949
25	0.2051
95.5	0.2177

The correlation coefficient R^2 value as previously yielded good results (R^2= 0.957) as described. The calibration step has been performed with the main goal of verifying hands-on experiment measurement results during the experiment although transfer function. See in Figure 11.

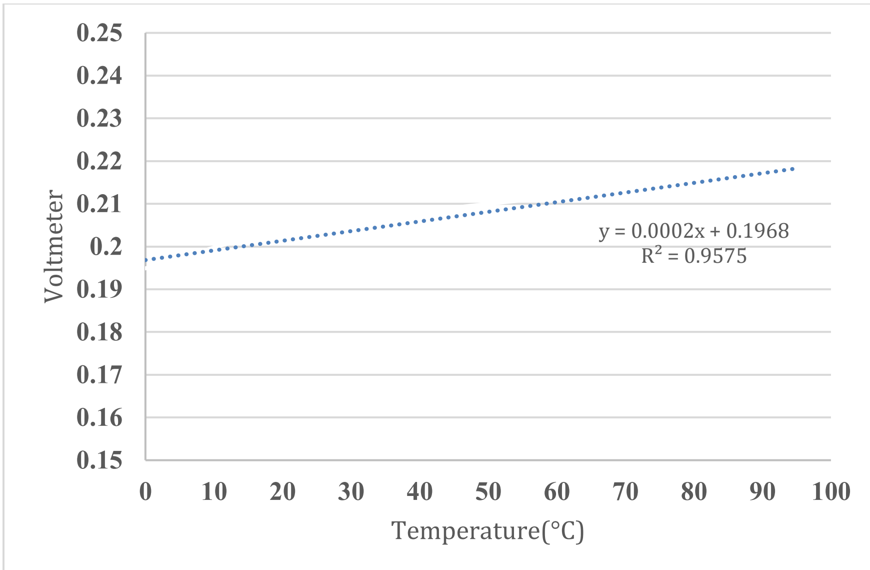

Figure 11: Thermochemistry calibration curve

Transportation Experiment Results

Decibel meter experiment results: The experimental observations with the reading from the decibel meter. The sound sensor intensity level is in dB after adding the transfer function equation in the spreadsheet (Equation 1).

$$20\ log_{10}(V_{in}/V_{out}) \qquad \textit{Equation 1}$$

Where V_{in} is the input voltage supply and V_{out} is the output voltage reading. The intensity of the sound sensor is in Volt/MS.

In the decibel meter experiment using an analog sound sensor to collect data from an indoor sound level, the bar chart represents the house (indoor). The sound increases with temperature change which moves faster during weather condition. The maximum and minimum decibel indoor reading is 26.26dB and 25.99dB level. Data is collected using ADALM 1000 (ALICE desktop) with transfer function. See in Figure 12.

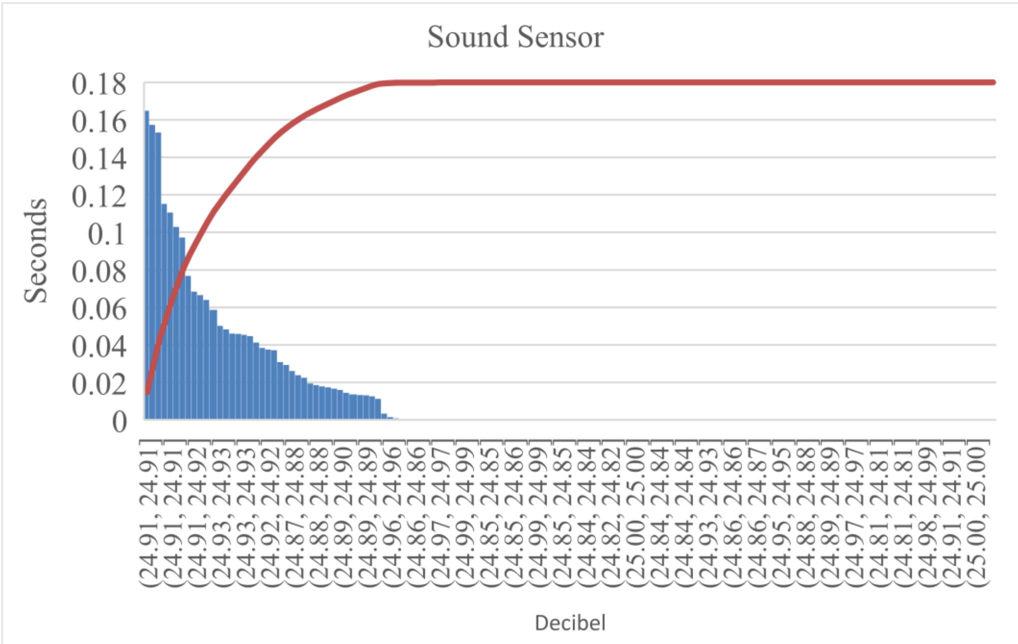

Figure 12: Graph of the sensor reading in decibel (x-axis indoor)

Table 4:The reading is collected from the experiment of the decibel meter

CA-V (Channel A-Voltmeter reading)	**Time (s)**	**Decibel (dB)**
0.282873	0	24.94758
0.28256	0.000001	24.95719
0.282716	0.000002	24.95238
0.28256	0.000003	24.95719
0.282716	0.000004	24.95238
0.282794	0.000005	24.94998
0.282873	0.000006	24.94758
0.282951	0.000007	24.94518
0.283185	0.000008	24.93799
0.283342	0.000009	24.93319
0.283498	0.00001	24.9284
0.283732	0.000011	24.92122
0.283967	0.000012	24.91405
0.284123	0.000013	24.90927
0.284201	0.000014	24.90688
0.28428	0.000015	24.90449
0.284123	0.000016	24.90927
0.284201	0.000017	24.90688
0.284905	0.000018	24.88541
0.285452	0.000019	24.86874

Using a sound sensor to collect data on I-295 (outdoor) while in a vehicle during off-peak hours, the bar chart represents the highways (outdoor). The line shows an increase of the sound produced at each time. The maximum and minimum decibel reading was 70.31dB and 9.04dB. CA-V is the output voltage from the sensor, dB (decibel) is value obtained after using the transfer function equation, and seconds is the time in milliseconds in table 5,and 6. This data is collected using ADALM 1000 (ALICE desktop). See in Figure 13.

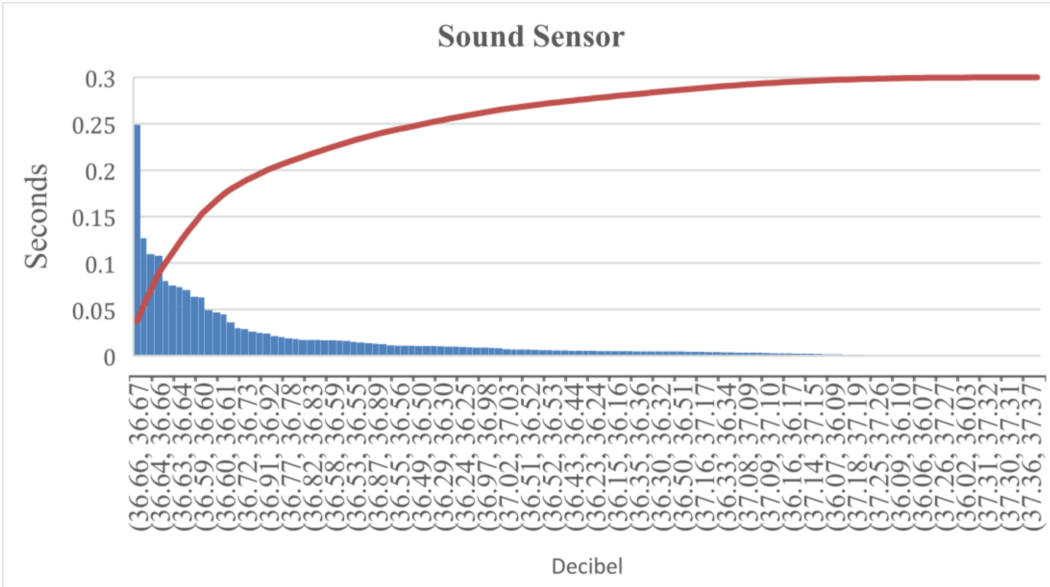

Figure 13: Graph of the sensor reading in decibel (x-axis outdoor I-695 East)

Table 5: The reading is collected from the experiment of the decibel meter

CA-V	Time (s)	Decibel (dB)
0.070355	0	37.03352
0.070355	0.000001	37.03352
0.070824	0.000002	36.97581
0.071293	0.000003	36.91849
0.071527	0.000004	36.88997
0.072074	0.000005	36.82378
0.072309	0.000006	36.79557
0.072621	0.000007	36.7581
0.072934	0.000008	36.72078
0.073247	0.000009	36.68363
0.073481	0.00001	36.65587
0.073559	0.000011	36.64663
0.073481	0.000012	36.65587
0.073638	0.000013	36.63741
0.073481	0.000014	36.65587
0.073559	0.000015	36.64663
0.073559	0.000016	36.64663
0.073403	0.000017	36.66511
0.073481	0.000012	36.65587
0.073638	0.000013	36.63741

In this decibel meter experiment using a sound sensor to collect data from an outdoor (I-495) motorist travel sound level, the bar chart represents the highway (outdoor). The line is the increase of the sound-producing at each level. Data is collected using ADALM 10000 (ALICE desktop) with transfer function. See in Figure 14.

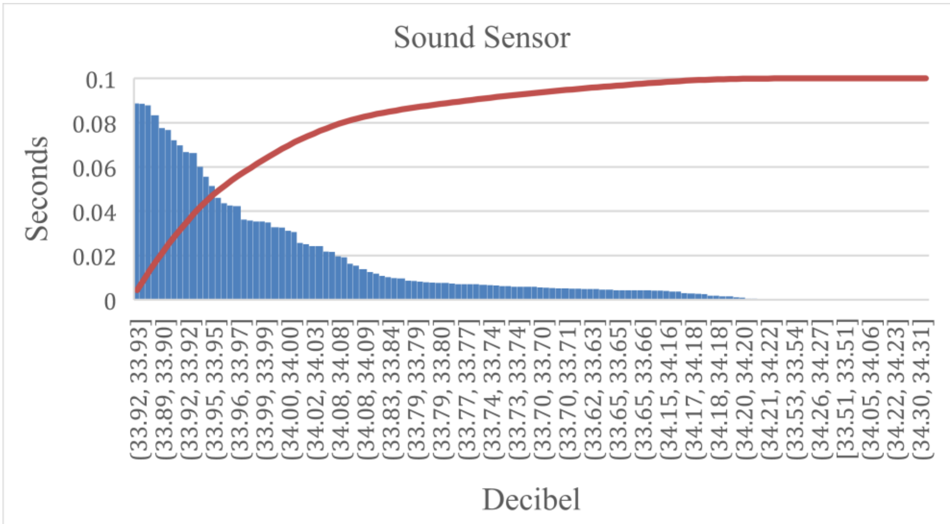

Figure 14: Graph of the sensor reading in decibel

Table 6: The reading is collected from the experiment of the decibel meter

CA-V	Seconds	Decibel (dB)
0.100525	0	33.93394
0.100368	0.000001	33.94746
0.100603	0.000002	33.92719
0.100525	0.000003	33.93394
0.100525	0.000004	33.93394
0.100525	0.000005	33.93394
0.100525	0.000006	33.93394
0.101306	0.000007	33.86667
0.102088	0.000008	33.79991
0.101853	0.000009	33.81989
0.10115	0.00001	33.88008
0.100056	0.000011	33.97456
0.099743	0.000012	34.00174
0.099587	0.000013	34.01537
0.099587	0.000014	34.01537
0.099587	0.000015	34.01537
0.099587	0.000016	34.01537
0.099509	0.000017	34.02219
0.099587	0.000018	34.01537
0.099665	0.000019	34.00855

Soil Moisture Experiment Result: The experiment is the hands-on laboratory to determine different soil samples content results with collected data from the hands-on laboratory. There were six lab specimens of varying moisture content measured and calibrate the soil sensor. See in Table 7.

Table 7: Soil Moisture data

			Soil Moisture Experiment			
Lab Sample	0%	5%	10%	15%	20%	25%
Digital (Soil Moisture Meter)	48%	85%	93%	90%	87%	69%
Analog (Soil Moisture Meter)	0.90%	1.50%	4.70%	4.10%	8.50%	9%
Sensor (M1K Reading)	0.1632	0.1263	0.1405	0.1437	0.1485	0.1569
Voltimeter (M1K Reading)	4.7944	3.8534	3.1846	3.9539	2.9888	1.7904

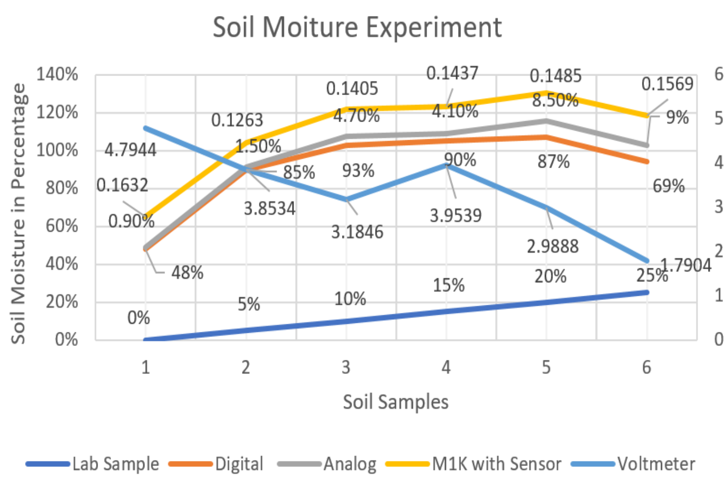

Figure 15: Validation of soil moisture sensor

This experiment was carried out using two standards graduated soil moisture meters that were purchased from a store to validate and calibrate the soil moisture sensor instrument with ADALM 1000 (M1K) by using this derived transfer function VBuffA[t]-5.89*(100/-2.911). Where VBuffA[t] is the input voltage. See in Table 6 for the calibration result curve. See in Figure 15.

Conclusion

Equipping students with a background in Experiment Centric Pedagogy will prepare them for future of STEM education success and they will be introduced to hands-on experiments research with active learning pedagogy in the laboratory and outside the laboratory. Chemistry and Transportation department hands-on lab experiments research activities are designed and tested during this research activity: potentiometry, thermochemistry, decibel meter, and soil moisture content. Incorporating different experiments and tools into various labs can increase students' interest, which could help with increasing productivity and knowledge. The research as a push for hands-on experiment design and additional research will be completed in the spring semester for a spectrophotometer and vehicle counter experiment.

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