Virtual Intensive Training for Experimental Centric Pedagogy Team Members: Effectiveness During COVID-19 Pandemic

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Gullie Consultants Services LLC, Owner, Dr. Kathy A. Gullie Ph.D. Dr. Kathy Gullie and her associates at Gullie Consultant Services LLC have been in education, assessment, program development and evaluation in New York State for over 30 years. A former New York State teacher for 36 years, Dr. Gullie is committed to the improvement of education for students in all areas and education levels. Collectively, along with members of the team, Gullie Consultant Services LLC. has served as external evaluators for school districts, federal and state agencies, not-for-profit organizations, and institutions of higher education in New York State, as well as from around the country. Some of our past clients include: The National Science Foundation, the U.S. Department of Education, The New York State Department of Education, New York State VESID, State University of New York at Albany/SUNY, the State University of New York at Binghamton/SUNY, New York Institute of Technology (NYIT), Howard University, Morgan University and New York City Board of Education.

More specifically, Dr. Gullie has served the principal investigator/evaluator on several educational grants including: an NSF engineering grant supporting Historically Black University and Colleges through Howard University, the Syracuse City School District Title II B Mathematics and Science Partnership grants, Building Learning Communities to Improve Student Achievement: Albany City School District, Educational Leadership Program Enhancement Project at Syracuse University and the University at Albany through the Teacher Leadership Quality Program. She holds an advance degree in Educational Theory and Practice from the University of New York/SUNY Albany, with experience in teaching educational methods at the master's level as well as an introduction to education courses designed to develop new interest in teaching careers. She has worked as an elementary classroom teacher developing specific curricula for gifted and talented students as well as inclusion classrooms in a school district eligible for rural and low-income programs. Dr. Gullie's experience and past projects qualify her for the position of evaluator to examine the impact of the Alliance: Pathways to Success in Engineering (PASE). Her experience and qualifications working with data from multiple educational projects and personal work with students give her an in-depth understanding of the developmental nature of students participating

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Abstract

The COVID-19 pandemic grounded the implementation of many research projects. However, with the intervention of the NSF research grant awarded to a Historically Black College and University (HBCU), with a specific goal to increase students' achievement in multiple STEM disciplines, the pandemic challenges provided opportunities to effectively achieve the project objectives. The Adapting an Experiment-centric Teaching Approach to Increase Student Achievement in Multiple STEM Disciplines (ETA-STEM) project aims to implement an evidence-based, experiment-focused teaching approach called Experimental Centric Pedagogy (ECP) in multiple STEM disciplines. The ECP has been shown to motivate students and increase the academic success of minority students in electrical engineering in various institutions. During the Summer of 2020, the ETA-STEM Trainees engaged in research activities to develop three instruments in their respective disciplines. This paper highlights the strategic planning of the project management team, the implementation of the ECP, a comprehensive breakdown of activities and an evaluation of effectiveness of the virtual training. The 13-week intensive virtual training using Canvas learning management system and zoom virtual platform provided the opportunity to effectively interact and collaborate with project team members. Some of the summer training activities and topics included: instrumentation and measurements in STEM fields, sensors and signal conditioning, assessing the performance of instruments and sensors, effective library and literature search, introduction to education research, writing excellent scientific papers, as well as the implementation and development of ECP curriculum with focus on home-based experiment. Prior to the training, ECP kits were shipped to the team and facilitators fully utilized the virtual platform to collaborate with team members. Overall, there was a great satisfaction and confidence with the participants designing three home-based experiments using the M1K and M2K analog devices.

Introduction and Background

Virtual training has been regarded as a tool for engaging a large participating audience without any limitation to physical space. An effective virtual training for educational development will not only utilize engaging live, virtual interactive classroom but also include the use of several active learning materials such as interactive breakout sessions, team workbook, annotated writing platform, engaging videos, and live scenarios audio clips, among others. According to Despain, 2020 [1], multiple studies have found that only 20% of the impact of training comes from actually learning the information while 80% comes from reinforcing that information. One of the most important considerations for an effective training program is how the curriculum is reinforced once it is learned. Due to the COVID-19 pandemic, which swept all activities from its normalcy across the globe, a virtual training was organized for ETA-STEM team members consisting of faculty and graduate assistants in six participating disciplines at the authors institution. In a systematic review by Gast et al., (2014) [2], several studies have shown that teacher professional development in teams results in changes in teaching practice [3][4], new knowledge about teaching [5], and changes in teachers' attitudes [3]. Another learning outcome of participating in a team-based professional development intervention was a change in a participant's teaching approach [6].

The Mobile Studio project, which was the basis for ECP, was developed by Rensselaer Polytechnic Institute to increase student's motivation and achievement in electrical and computer engineering. ECP is a teaching technique that utilizes hands-on-activities through an inexpensive, safe, and portable electronic instrumentation system that can be used in classrooms and student laboratories to teach STEM concepts. ECP implementation can be varied based on different instructional use (instructor demonstration, cooperative and independent student setting) and learning setting (traditional classroom, lab setting, homework) [7]. ECP is a valuable STEM teaching approach, because using electronic instrumentation to make scientific measurements is common in all STEM disciplines. The learning process of ECP is mainly driven by experiments that utilize a Mobile Studio I/O Board or Analog Discovery (AD) Board. The Studio I/O Board or Analog Discovery is a personal electronic instrument that is inexpensive and portable, and can be connected to a computer. Its portability makes it easy to be utilized at any learning setting (classroom, laboratory or at home). Astatke et. al. [7] investigated the relationship between learning settings (classroom, laboratory/home) and instructional use of the Analog Discovery Board on potential student outcomes. Their study noted that faculty and students benefited from the use of the AD Boards and there were increases in constructs reflecting required affective pre-requisites to learning, including interest in content, motivation to learn, and confidence in ability to learn.

Fowler and Schmalzel [8] stressed the importance of measurements in the STEM field as measurements are precursor to control, management, and improvement of engineering systems. They also noted that instrumentation is needed to perform the measurements. Hence, for effective instrumentation, sensors must reliably and accurately represent the phenomenon that is being observed. Fowler and Schmelzel [9] further noted that every measurement has a target; the measurand that drives the measurement process and a single sensor or collection of sensors that is needed to selectively transduce the desired measurand. The characteristics of a few sensors like; strain gauge, LVDT, phototransistor, microphone, thermocouples, etc, were presented in their paper.

Elhajj et al [10] opined that instrumentation and measurement is one of the most interdisciplinary engineering domains, that serves a broad range of applications. They developed a course on Applied Instrumentation for Civil Engineering students and the course was offered in parallel for Civil and Environmental Engineering (CEE) and ECE students at the American University of Beirut. The developed course is a three-credit course with two credits of lectures (50-minute lectures twice a week) and one credit of laboratory (3-hours). Elhajj et [10] gave the catalogue description as: "A design course for complete instrumentation system, including measurements, sensors, data acquisition, and component integration. Application areas and course projects include laboratory measurements and testing, geotechnical, structural health monitoring, environmental, and other civil applications. The course is complemented with a set of laboratory experiments". While the students outcomes were as given as follows: (1) selection of appropriate sensor for a specific application, (2) design and implementation of appropriate signal conditioning needed for a specific sensor, (3) design and implementation of a data acquisition system using National Instruments' (NI) LabView, microcontrollers and programmable logic controllers (PLCs), (4) calibration of measurement systems but using standards, (5) assessment of the performance of sensors and (6) description of the functionality of geotechnical, environmental, structural health monitoring, thermal, and mechanical sensors. The details of various sensors used in civil engineering (geotechnical, environmental, structural health monitoring, thermal, and mechanical sensors) were also presented in the paper.

With support from NSF, the overarching goal for this project, the Adapting an Experiment-centric Teaching Approach to Increase Student Achievement in Multiple STEM Disciplines (ETA-STEM), project is to adopt evidence based, high impact pedagogical techniques that have been successful in promoting motivation and enhancing achievement among African Americans in STEM fields. The project is being adapted across seven STEM disciplines (civil engineering, industrial engineering, transportation systems, biology, computer science, chemistry, and physics) at the authors' university. The project entails a widespread adoption/diffusion of this active learning pedagogy through the development of new curriculum to utilize portable hands-on mobile devices, targeting selected cohorts of students from their freshman to senior year.

The objective of this paper is to present the results of the virtual training conducted during the summer of 2020 for ETA-STEM faculty and graduate trainees in the participating STEM disciplines over a period of thirteen weeks. The project seeks to develop hands-on experiments for adoption in the Fall 2020 semester making use of the identified instruments and sensors.

Training Description

During the Summer of 2020, ETA-STEM trainees (graduate students) engaged in research activities and the development of three sensor-based hands-on activities in their respective disciplines. The programs began with a workshop on June 3 - 4 and continued through the summer with scheduling for specific content and practice each week for 13 weeks. Weekly topics included: overview of instrumentation and measurements, getting started with M1K and M2K boards, hardware review, introduction to signal conditioning, how to build a circuit on a breadboard, participating in the ASEE Annual conference, assessing the performance of an instrument, calibration of distance sensor, temperature sensor example, reviewing literature on ECP/Hands-on learning/Mobile Studio/Analog Discovery/ADALM1000/ADALM2000, writing papers and reports for STEM projects and introduction to education research.

The specific objectives of the summer activities focused on:

- Receiving formal training in the development of instrumentation via a Canvas Course
- Selecting the appropriate sensor for a specific application
- Designing and implementing the appropriate signal conditioning needed for a specific sensor
- Designing and implementing a data acquisition system using M1K and M2K or microcontrollers (advanced),
- Calibrating a measurement system using standards
- Assessing the performance of a sensor or instrument (accuracy, repeatability, etc.)
- Describing the functionality of load/strain, vibration, inclinometer, water/air quality, salinity, pH, displacement/location/position, velocity/distance/acceleration, time, sound,

pressure, photodetector, spectrophotometer, thermal (resistance/thermistor/ thermocouple), CO2/O2 sensors

Additionally, students were asked to:

- Develop a minimum of three instruments to be available for use in the Fall 2020 semester.
- Develop research skills for example, library search, reading a research paper, literature review, writing reports, writing papers, research presentations.
- Present a final paper and final presentation.
- Document their activities through weekly presentations, an online engineering notebook, changes to courses when adapting ECP, a laboratory manual, and bill of materials.
- Attend research meetings where students report and demonstrate their activities.

Training Modules

[1] Effective Library and Literature Search

A session on the effective use of the University's library for literature search was conducted on Tuesday July 14, 2020 by one of the authors (RJ) who is the Head Access services/systems. The presenter demonstrated how to access the library resources to obtain quality research papers from several journals while off-campus. The database from another university which has partnered with the university can as well be accessed, thus enabling the trainees to gain vital information without any off-campus limitation due to Covid-19.

Furthermore, an article was assigned to the trainees to read in preparation for writing a research paper. In the article, the author developed an adaptation of techniques to read papers with a practical approach and a three-pass method. According to Keshav [8], researchers must read papers to review them for a conference or a class, to keep current in their field, or for a literature survey of a new field. The author also described how to use this method to do a literature survey. As mentioned in the paper out of the three-pass method, the first pass gives a general idea about the paper like title, abstract, introduction, and conclusion. The second pass is the paper's content, but not its detail, and the third pass helps to understand the paper in depth. The three-pass method helps the researchers to search the related papers and develop the ideas and thoughts about the topic. The author has also said that it helps to estimate the amount of time required to review a set of papers and adjust the depth of paper evaluation depending upon the needs and the availability of time of the researchers [8].

[2] Introduction to Education Research

On Thursday, July 23, 2020, one of the co-authors (KB) gave a presentation on conducting educational research. He presented the three types of research methods; quantitative, qualitative and mixed methods. According to him, qualitative research focuses on understanding the meaning of words, languages/terminologies, uses emerging questions, and collects data in participant's settings. This type of research involves the use of interviews/observations for collecting data. On the other hand, quantitative research examines relationships among measurable variables called numerical variables. Survey instruments that produced numerical data can as well be used for performing statistical analysis using Minitab, SAS, SPSS among others. Quantitative research designs are also called correlational design, survey research, causal-comparative research, and experimental research.

The mixed methods research collects both quantitative and qualitative data. This method uses distinct designs that involve theory. The following are ways of doing mixed methods – (1) concurrent (qualitative and quantitative data are collected at the same time) (2) sequential (first give out a survey to students and then conduct a follow-up).

The three components involved in an approach to educational research was presented by the presenter. These components are put together in a framework consisting of philosophical worldviews, designs, and research methods. The statistical analysis to select when analyzing data depends on research questions and type/size of data, the common ones are t-test, ANOVA, COVA, regression, etc. If the goal is to compare groups of data or difference, we use a t-test, ANOVA. For finding strength of association or to relate variables, we use associational inferential statistics such as linear or multiple regression. But if the goal of the analysis is just to summarize data, then we use a descriptive statistic such as a mean, percentage. Regression is used to predict the outcome of the dependent variable from two or more independent variables. Conclusively, the presenter recommended the following strategies to be considered before applying the research methods in our study:

- Research site/location
- Sample size/participants
- Types of statistical analysis used
- Limitations and delimitations of the study
- Impact of the study/generalizability

[3] Writing Papers for STEM Projects

The session on "writing research papers for STEM projects" was conducted by one of the co-authors (MS), on July 9, 2020. It was a very insightful session. The presenter gave detailed information on writing research papers, the review process, and publications. The session highlighted why people write and publish papers. According to the presenter, there are two kinds of motivations; altruism and self-interest. In the process of writing a new research project, we need to begin with a literature search. The main objective of the search is to evaluate the state of our communal knowledge on a topic, establishing an in-depth knowledge of a specific topic, before starting on a quest of adding to that knowledge. Existing literature can be obtained from several search websites/platforms such as the university library database, Science Direct (Elsevier), Google Scholar, ResearchGate. The presenter gave the format of scientific/technical articles as they proceed from Abstract to References. Furthermore, the presenter stated that one major rule to differentiate a review article from a research article is that the introduction which contains the literature review should not be more than 20-25% for a research article while 75-80% of the entire work will be the author's contributions.

Observations of Presentations

On August 25, 2020, the project evaluators, two of the coauthors, observed the virtual Graduate Student Trainees' final presentations. These presentations outlined each group of students' summer activities, research, and their explanation of how they developed their sensors. Table 1 shows the presentation schedule.

Table 1: Agenda of Presentations August 25, 2020

Time	Topic
11:00 AM	Overview of Summer Activities
11:05 AM	Summer Activities/Three Sensors Presentation: Industrial Engineering
11:20 AM	Summer Activities/Three Sensors Presentation: Civil Engineering
11:35 AM	Summer Activities/Three Sensors Presentation: Transportation Systems
11:50 AM	Summer Activities/Three Sensors Presentation: Physics
12:05 AM	Summer Activities/Three Sensors Presentation: Chemistry
12:20 AM	Summer Activities/Graphical User Interface Development: Computer Science
12:35 AM	Wrap up and General Comments

Observation of student presentations revealed that students were confident in their work, presentations were complete and well thought out. During the presentations students were able to clearly explain their perspective and the process they used, as well as answer questions posed by faculty. Comments by faculty supported students learning and provided input and guidance for future work. Table 2 shows the results of the evaluation survey conducted after the training. All the trainees agreed that their knowledge increased while developing various experiments during the training, they also consented that they have developed interest in the subject area because of the experiments developed. Only 33 percent agreed that they had an uneasy and upset feeling while doing the experiments. A few of the participants commented that “It increases my curiosity especially in setting up the board, then it's interesting to work with the portable devices rather than carrying oscilloscope or other bigger instruments all around.” And “I could see how things work and what I read in the books made all the more sense”, while others stated that “The devices engaged and made me curious fully in exploring and performing the experiments. The interesting part was, I was performing the experiments by myself at my own apartment.” And “It gave me an opportunity to learn and know about the devices and other parts that were included in the experiment.

Table 2: Faculty and Graduate Students Outcomes Associated with Experimentation

Statement	% Agree*
My knowledge increased as a result of experiment	100
I developed interest in the subject as a result of my experiment	100
I had an uneasy, upset feeling while doing my experiment	33

**Strongly agree and agree *n =15*

ECP Implementation in Fall 2020

During the Fall of 2020, faculty and undergraduate engineering students conducted experiments in Biology, Industrial Engineering and added new courses in Transportation Engineering, Environmental Engineering and Physics in implementing the ECP using hands-on devices. COVID-19 still impacted instruction and most courses were still online, so lab materials were distributed to students for performing home-based hands-on lab. The following lab courses stemmed out of the ECP summer training program.

[A] Transportation Engineering

Course: TRSS 415 – HIGHWAY ENGINEERING

In this laboratory, students are required to determine the decibel level using a sound sensor and ADALM 1000 (M1K). Figure 1 shows the description of the Sound level (Decibel Meter) experiment in the laboratory.

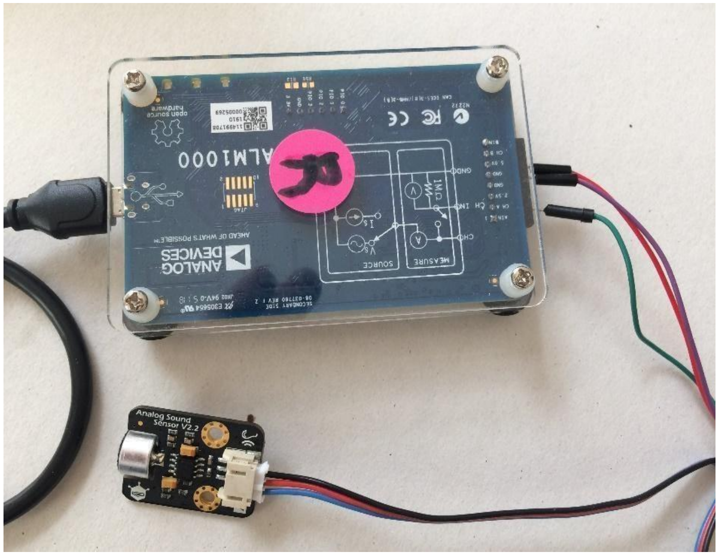

Figure1: Analog sound sensor and ADALM 1000

Laboratory Procedure

Using the ADALM 1000 with the sound sensor to measure sound in decibel

1. The student is required to save reading with a different FILENAME each time
2. The student is required to input the mathematical function into the excel spreadsheet

Transportation Noise Lab Data Collection

Each group member is expected to collect information at the following locations & times:

a. Inside residence during the day
b. Inside residence at night
c. Outside of residence during the day
d. Outside of residence at night

For each location, the student must do the following:

a. Record 3 mins of sound

b. Record the time of data collection

c. Note any irregularities in sounds that you notice such as people yelling, car horns, motorcycles, etc.

[B] Civil Engineering

Course: Environmental Engineering Lab 1: pH, ACID, and BASES

An experiment on determining the pH values of different solutions was conducted in Environmental Engineering lab course. A pH value is a number that illustrates the acidity and basicity of a solution. This value ranges between 0 and 14, with values between 0 and 7 indicating an acidic solution while values between 7 and 14 indicates a basic solution. Figure 2 shows a typical example of a pH scale when a universal indicator is added. A universal indicator is an indicator made of a solution of several compounds. This solution indicates a wide range of pH values to show acidity and alkalinity of a solution. For example, it may contain compounds like thymol blue, methyl red, bromothymol blue, thymol blue, and phenolphthalein. This means that the universal indicator contains a mixture of other types of indicators. Other types of pH indicators include, litmus paper, phenolphthalein, bromothymol blue, and methyl red. Generally, a pH indicator is a substance which when added in small quantity to a solution with unknown pH changes the color of that solution.

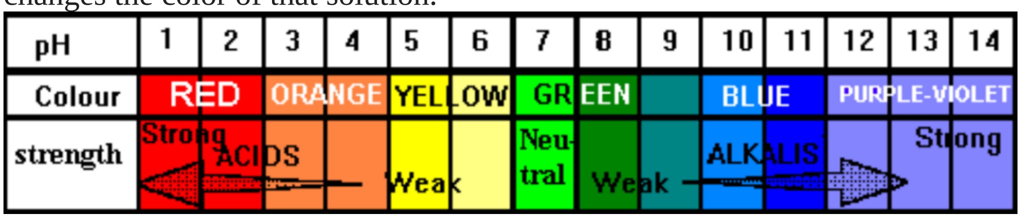

Figure 2: pH Scale when a Universal Indicator is Added

The indicator to be used in this Hands-on laboratory setup shown in Figure 3, is red cabbage which is obtained from natural sources. This indicator will yield a color depending on the pH of the solution. The color of the solution when these indicators are added to a solution gives an approximate pH estimate of that solution, when compared to the standard pH value. However, if an exact quantitative value is needed, a pH meter is used. A pH meter has a special probe capped with a membrane which is sensitive to hydrogen ions. For this hands-on experiment, an analog pH sensor is used.

[C] Physics

Lab Experiment: Measuring the impedance profile of a loudspeaker [12]

In this experiment, the students made use of the speaker provided to observe the impedance curve with setup shown in Figure 4. The moving system of the loudspeaker is modeled as a certain mass which is suspended by a spring possessing a certain frequency known as resonant frequency Fs. At Fs, the voice coil is vibrating at maximum peak to peak amplitude and velocity and the system is at maximum impedance, Zmax. As the frequency approaches resonance, the system impedance rises and is inductive in nature, at resonance impedance is resistive in nature, and as impedance drops below resonance it is capacitive in nature. Zmin is the minimum impedance value in which the system is resistive in nature and speaker's nominal impedance can be derived. The materials used are loudspeaker, two 100Ω resistors connected in parallel, ADALM1000 analog device and solderless bread board. Table 3 shows the statistics of total ECP courses implemented in the Physics department during the Fall 2020 semester. The table shows the number of students in each of the course sections and the breakdown summary of those students that did not benefit from the implantation either as result of technological challenges or absence in person or abroad.

3a.pH sensor with M1K device 3b. pH solutions

Fig.3 pH experimental Setup

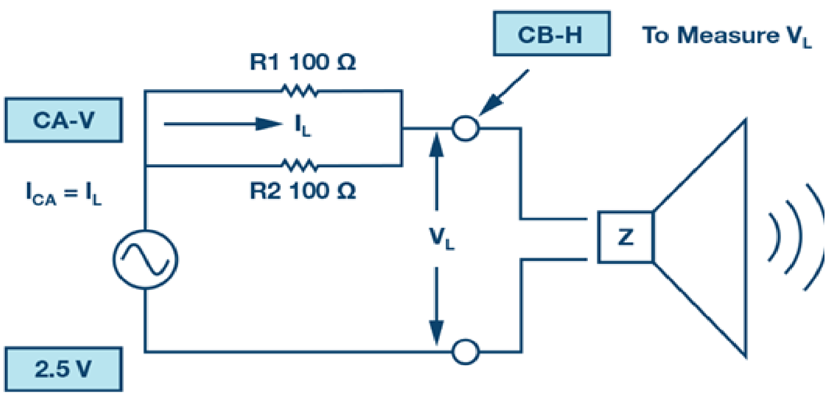

Fig 4: Speaker setup. Adapted from [12]

Table 3 Implementation Statistics in Physics

	PHYS 206L.150	PHYS 206L.004	PHYS 206L.001	EASC 205.001	PHYS 205L.001
Students Number	n = 8	n = 13	n = 19	n =30	n = 18
ECP Implementation	4	6	13	-	-
Non- ECP Implementation	4	7	6	22*	18**
Technological Challenges	1	2	4		
Non-Class Attendance	2	4	2		
Being Out of the US	1	1	2		

*used for evaluation of remote teaching in a non-practical class
**used for evaluation of remote teaching in a practical class that did not use ECP STEM tools

Conclusion

This paper presented the summer virtual training program organized for the ECP team members for the awarded NSF STEM project, as well as the outcomes of the training in implementing ECP home-based hands-on experiment in the participating STEM courses. The trainees comprised mostly graduate students and faculty members. The student team engaged in research activities leading to the development of three sensors in their respective disciplines. The training program began with a two-day workshop and continued throughout summer with scheduling for research studies and presentations each week for 13 weeks. Additional courses were implemented in environmental engineering, transportation engineering and physics department. The entire STEM trainees reported that the analog devices used during the training session engaged and made them curious fully in exploring and performing the experiments. The ECP team members became more confident in guiding their students to conduct home-based hands-on lab experiment safely and effectively.

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References

1. Despain, M. (2020). What does effective virtual training look like? Find out here. Retrieved March 06, 2021, from https://leadershipchoice.com/what-does-effective-virtual-training-look-like/
2. Gast, I., Schildkamp, K., & van der Veen, J. T. (2017). Team-based professional development interventions in higher education: A systematic review. *Review of educational research*, *87*(4), 736-767.
3. Meirink, J. A., Imants, J., Meijer, P. C., & Verloop, N. (2010). Teacher learning and collaboration in innovative teams. *Cambridge Journal of Education*, *40*, 161–181. doi:10.1080/0305764X.2010.481256
4. Vescio, V., Ross, D., & Adams, A. (2008). A review of research on the impact of professional learning communities on teaching practice and student learning. *Teaching and Teacher Education*, *24*, 80–91. doi:10.1016/j.tate.2007.01.004
5. Kafyulilo, A. C., Fisser, P., & Voogt, J. (2015). Supporting teachers learning through the collaborative design of technology-enhanced science lessons. *Journal of Science Teacher Education*, *26*, 673–694. doi:10.1007/s10972-015-9444-1
6. Deni, A. R. M., & Malakolunthu, S. (2013). Teacher collaborative inquiry as a professional development intervention: Benefits and challenges. *Asia Pacific Education Review*, *14*, 559–568. doi:10.1007/s12564-013-9280-y
7. Astatke, Y., & Connor, K. A., Newman, D., Attia, J. O., & Nare, O. E. (2016, June), *Growing Experimental Centric Learning: The Role of Setting and Instructional Use in Building Student Outcomes* Paper presented at 2016 ASEE Annual Conference & Exposition, New Orleans, Louisiana. 10.18260/p.25427
8. Fowler, K.R., and Schmalzel, J.L. (2004b). Why do we care about measurements? (Part 1 in a series of tutorials in instrumentations). *IEE Instrumentation & Measurement Magazine 1094-6969/04. September 2004.*
9. Fowler, K.R., and Schmalzel, J.L. (2004a). Sensors: The first stage in the measurement stage (Part 2 in a series of tutorials in instrumentations). *IEE Instrumentation & Measurement Magazine 1094-6969/04. March 2004.*
10. Elhajj, I.H., Gurunian, M., Rishani, N. (2016). Applied Instrumentation for Civil Engineering at the American University Beirut. *IEE Instrumentation & Measurement Magazine 1094-6969/16. December 2016.*
11. S. Keshav. (2007). How to read a paper. *ACM SIGCOMM Computer Communication Review. Vol. 37. N.3.*
12. Getz, R. (2021). Activity: Measuring a Loudspeaker Impedance Profile. Retrieved from: https://wiki.analog.com/university/courses/electronics/electronics-lab-speaker