The impact of teaching noise detection and control strategies among historically black college and university student using hands-on pedagogy on student's motivation and curiosity

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ABSTRACT

Noise engineering is not a new field of study, but statistics showed that experts in the field are on a decline. Observing that motivation and curiosity are among the hallmarks of any workforce development pipeline, the study developed an experiment-centric pedagogy to detect and measure noise from pollution using low-cost hands-on devices with the aim of motivating learners. The study design was a pre- and post-test method. The learners were enrolled in a transportation course and the noise detection and measurement strategies course module was used for the study. Motivated Strategies Learning Questionnaire was adopted for the study. Learners' response to the use of technological tools incorporated in learning was predominantly positive revealing that the learners' gain extensively. More so, significant improvement was observed in the task value and expectancy component of leaners ($p<0.05$) and overall, there was an increase in their motivation at the post-test. Significant improvement in academic performance of learners was also observed at post-test ($p<0.05$). It is therefore posited that there is need for effective engagement with learners with similar low-cost hands-on to lead to better understand and motivation that can lead to development of workforce in noise engineering.

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1. INTRODUCTION

Traditional way of teaching and learning is fast less productive as evidences have posited in literature [1]–[3]. Also, the level of engagement of learners in active learning processes has been found to aid knowledge retention, clarity of understanding in concepts, and motivation to choose a career within the field of study [4], [5]. It is imperative to therefore find more engaging and effective strategies of impacting knowledge to this millennial learner with the goal of motivating them to continue in the chosen field as well as stir up their curiosity and critical thinking which is link to success rate, innovations, and inventions.

Experiment-centric pedagogy, ECP, is a learner-centric approach of teaching utilizing low-cost, portable, and safe instruments at various setting (classroom, home, or laboratory) to deepen the level of understanding and engagement of learners on various concepts in STEM fields. Findings revealed that through the implementation of ECP in engineering departments of 13 historically black colleges and universities (HBCUs), leaners level of motivation increased significantly and there was higher level of engagement in the learning process [6]. The demonstration of various measurement techniques in some concepts in STEM fields cannot be overemphasized as not just a tool to stimulate learning among learners but also serves as a prerequisite to enable control, management, mitigation, and setting up policies and mitigation strategies[7]. Implementing the measurement of noise associated with some transportation infrastructure is therefore posited to improve learning outcomes, learners' motivation, and most importantly, lead to workforce development in noise engineering.

Inarguably, some concepts in engineering are best demonstrated than others while others could be more abstract than others. In all of these, leaners' motivation is essential to support an effective learning environment. Motivation as described by Garcia and Pintrich [8] to be essential for effective and productive learning because it drives students to engage with the subject, persevere through difficulties, and apply their knowledge in real-life circumstances. Motivated students set goals, devise effective study routines, and track their own learning progress. Furthermore, motivation effects cognitive processing and the ability to link concepts, affecting the overall quality of learning [8]. In addition, motivation is a critical component of successful learning and can have a substantial impact on a student's academic achievement and prospects among which is the nation's workforce development.

Evidence exists in literature that activity-based learning result in increased motivation, improved academic performance, and higher level of engagement of learners in the learning process [4]–[6], [9]. Julia and Antoli [2] found in a study that when learners are engaged in activities-based learning create an interesting and engaging learning opportunity for STEM learners. ECP, an example of activity-based learning is therefore proposed in this study to provide answers to the following questions:

(i) What is the change in the level of motivation of learners that took part in the study?
(ii) What is the change in performance of the learners?

2. METHODOLOGY

The implementation of ECP was conducted in a transportation course using electronic instrumentation.

2.1. Noise Detection Experiment

During the highway engineering class in the Fall 2021, a noise experiment was carried out. A laptop, an analog sound sensor, an ADALM 1000 (M1K), and three jumper wires are used in the experiment. This noise measurement will assist students in understanding sound and comparing noise levels in various locations. The experimental setup is depicted in Figure 1.

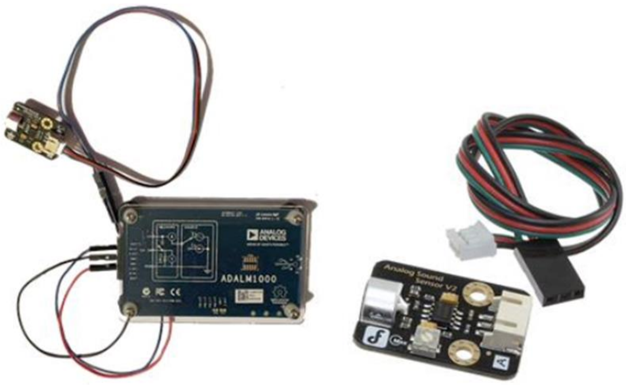

Figure 1: Noise Experiment Laboratory Equipments

Learners' were exposed to fundamental concepts such as frequency, noise, and loudness prior to the start of the experiment. Students were instructed on how to measure various sound sources. Using the sound decibel mobile app, the students were able to connect these principles to real-life circumstances. However, the sound decibel mobile app and a mobile phone were used in Fall 2022 to perform sound experiment. Students were assigned tasks to collect data from various sources of sound using the smartphone app and they were able to analyse the obtained data. Figure 2 depicts a graphical depiction of the mobile app utilized.

Figure 2: (a) Apple (iPhone) Apps (b) Android Apps

2.2. Data Collection and Analysis

Data collection was done using the Motivated Strategies Learning Questionnaires (MSLQ) [9] and signature assignment that shows pre and post-performance of students and classroom observation assessment feedback obtained during the class session. A rubric evaluation was used to measure the student's understanding of noise detection and control and was termed signature assignment.

The MSLQ was adopted to assess the efficacy of ECP implementation. The MSLQ comprises of the following constructs: intrinsic goal orientation, expectancy component, metacognition, task value, test anxiety, peer learning and collaboration, interest epistemic curiosity, and deprivation epistemic curiosity. A 7-point Likert-type scale consisting of statements that pertains to all the constructs except from interest epistemic curiosity and deprivation epistemic curiosity which were on 4-point Likert scale. The Littman and Spielberger measurement model analyses student’s curiosity [10]. A descriptive analysis was also conducted to determine the significance of the constructs for the obtained pre and post data. The Classroom Observation Protocol for Undergraduate STEM (COPUS) developed by Smith et al [11] was used to measure learners’ engagement during implementation of ECP. This methodology was used to indicate how much time instructors and learners spend during class sessions as well as provide feedback on effectiveness of teachers’ instructional strategies. The classroom observation evaluation has 25 indicators and is split into two divisions “what the learner is doing” and “what the instructor is doing.”

While examining the classroom observation results, Velasco et al. [12] suggested using a bar chart to demonstrate instructor-student behaviour, estimated in percentages for a 2-minute interval during the lab session. The learners were provided with a signature assignment to assess their performance and the same questions were posed before and after the experiment. The hands-on device was also used to evaluate students’ learning outcomes such as ability to design and execute experiments as well as evaluation and interpretation of data. Figure 3 depicts a well-developed course framework where ECP is executed, and it is organized into four sections.

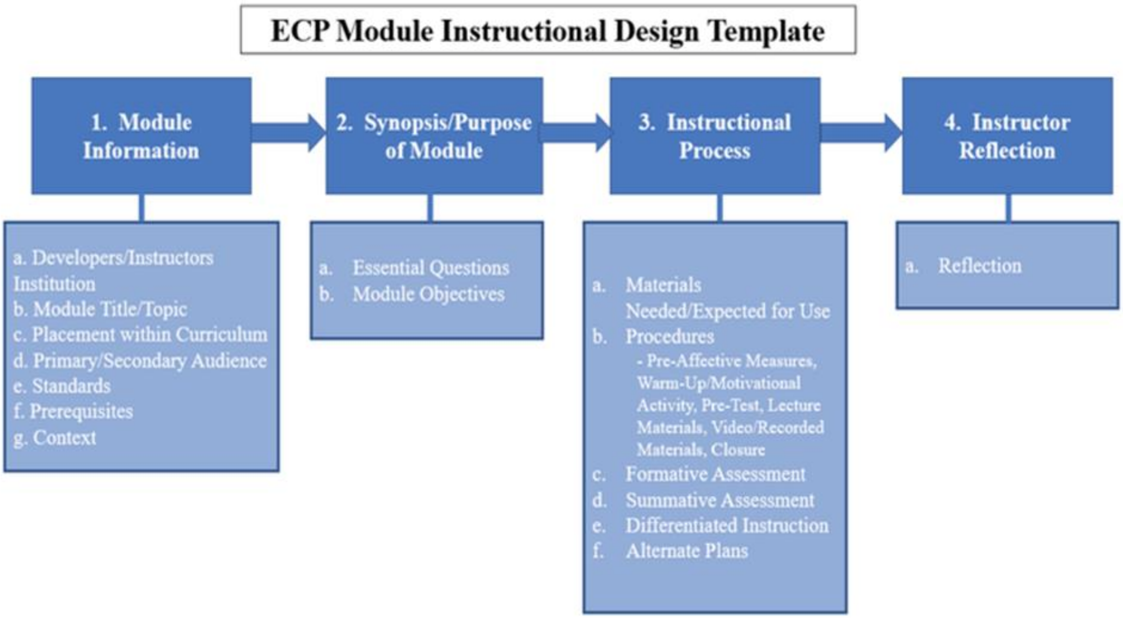

Figure 3: ECP Instructional module design [9]

A total of 25 learners' data were found fit for the data analysis after data cleaning. The data was subjected to descriptive statistics and inferential statistics at confidence level of 95%.

3. RESULTS AND DISCUSSION

The mean ± standard deviation scores of learners from the motivated learning strategy questionnaire is revealed in Table 1. The result showed that for most of the constructs, there was an increase in the learners self-rating. Intrinsic goal orientation serves to examine the learners' inward level of motivation towards the concepts taught using ECP. The post-test score was found to be higher than the pre-test scores (5.54±1.24 vs. 5.39±1.17). The construct, task value represents the learners' perspective of the importance of the concepts demonstrated with hands-on learning and the result showed that there was a significant increase from the pre-test (5.25±1.27) to the post-test (5.75±1.16) ($p<0.05$). This is similar to the findings of [13] where it was reported that activity based learning significantly improved learners task value. Chiang et al [13] posited that learners tend to focus strongly on tasks they found important while ignoring others. The results in Table 1 also indicated that the expectations of the learners improved from pre-test (5.64±1.18) to post-test (6.17±1.09) significantly ($p<0.05$). Other constructs that showed an increase in learners score were metacognition, critical thinking, epistemic curiosity (interest or deprived). There was a decrease in score for Peer learning and collaboration. This could be attributed to students having to own and use their personalized devices for the implementation of ECP.

Table 1: Mean Scores of Learners Motivation

Constructs	**Pre-Test**	**Post-Test**	**Mean Difference**	**t-test p-value**
Intrinsic Goal Orientation	5.39±1.17	5.54±1.24	0.14	0.45
Task Value	5.25±1.27	5.75±1.16	0.50	0.02*
Expectancy Component	5.64±1.18	6.17±1.09	0.52	0.01*
Test Anxiety	4.59±1.62	4.68±1.93	0.09	0.81
Critical Thinking	4.88±1.01	5.14±1.77	0.26	0.46
Metacognition	5.41±1.00	5.43±1.17	0.02	0.92
Peer Learning and Collaboration	4.13±1.65	3.63±1.91	-0.50	0.12
Interest epistemic curiosity	3.24±0.67	3.29±0.60	0.06	0.65
Deprived epistemic Curiosity	2.54±0.68	2.66±0.74	0.12	0.49

* Constructs that have significant difference between pre-test and post-test

Results in Figure 4a and 4b revealed the simultaneous activity that goes on in a classroom where experiment-centric pedagogy was utilized in instructing student on noise detection and measurement using low-cost mobile, safe and portable devices. At 46.43% of the total class time, learners were actively listening to the instructors, and they were engaged in other activities at about 53.6% of the time. Such activities include asking questions (10.71%), answering questions posed by instructors (25.00%), and working in group during breakout sessions. Figure 2b revealed that at about 32.43% of total class time, instructor was lecturing and engaged in other activities for the other 67.57%. Among such activities include posing questions (18.92%), one-on-one extended discussion with learners (10.81%) and posing questions to learners (10.81%). This result revealed a change in class dynamics where instructors have been found engage in longer period of lecturing and answering questions from learners [14].

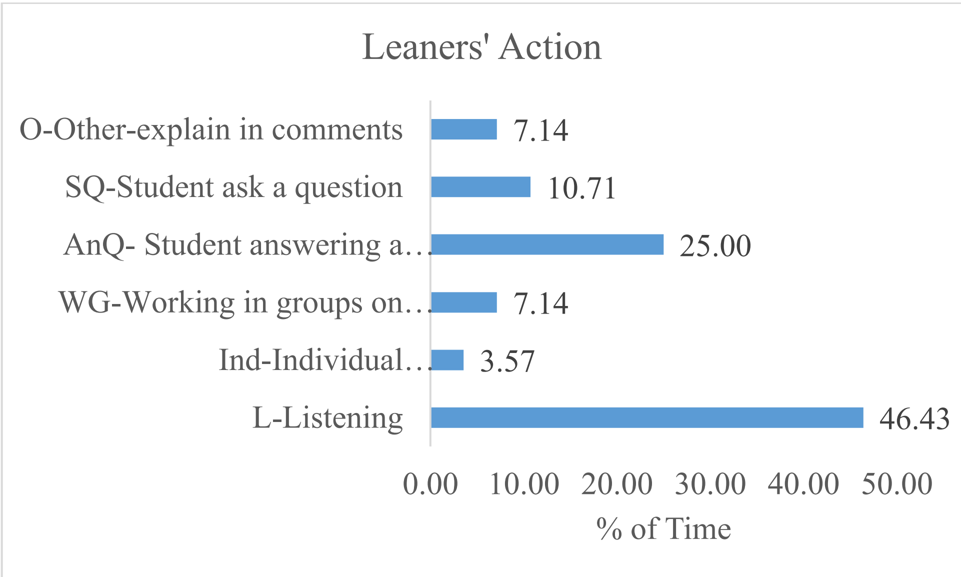

Figure 4a: Learners’ action during the implementation of ECP Noise detection and measurement module

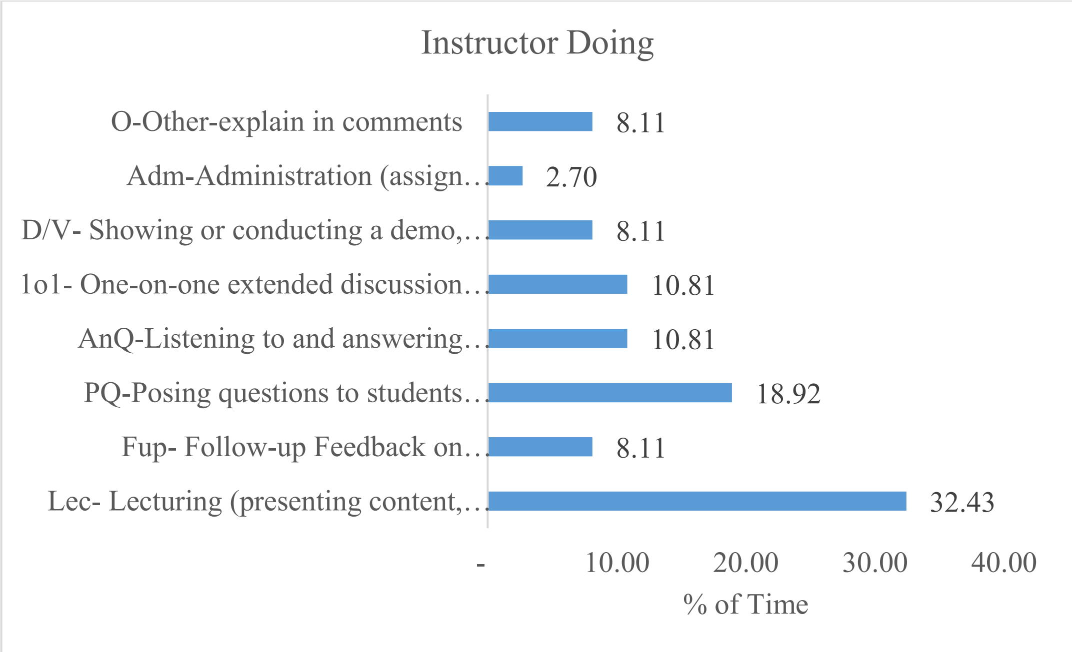

Figure 4b: Instructors' action during the implementation of ECP Noise detection and measurement module

Figure 5 shows the minimum, maximum and average performance of learners in the special signature assessment used to evaluate learners' comprehension and reproducibility of knowledge. The result showed that there was a 40.35% increase from pre-test to post-test in the average learners' performance (57.00% - 80.00%). This change was found to be significant (p<0.005). The impact of hands-on activities in performance as also been documented in literatures [15]–[17].

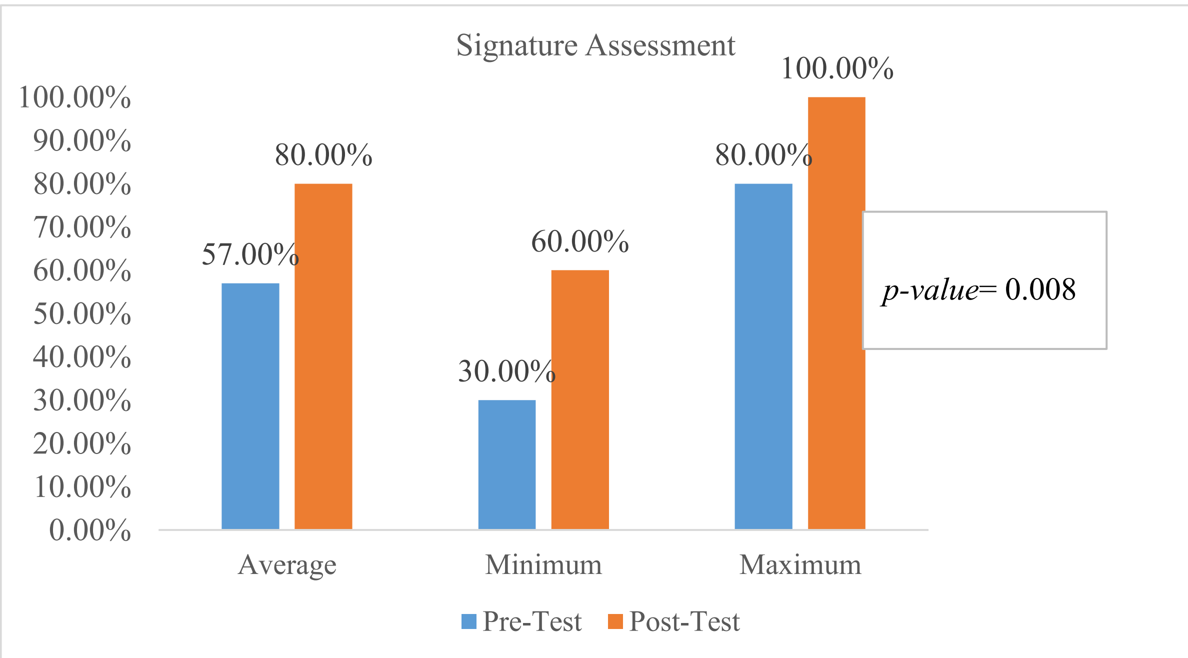

Figure 5: Signature Assessment of Learners in Noise Detection and Measurement

4. CONCLUSION

The study investigated the impact of use of low-cost, portable, and safe devices incorporated in teaching and learning noise detection and measurement at one of the historically black colleges and universities in the USA. This pedagogy was herein referred to as experiment-centric pedagogy. Results of 25 learners who actively and fully participated in the study were presented. The study found that the use of this pedagogy improved overall leaners' motivation and curiosity, and significantly in their task value and expectations. More so, their performance was found to be significantly improved post-implementation of the pedagogy. It is therefore posited that when learners are motivated and they see result for their academic input in terms of their performance, there is high probability that they tend to continue through the path of learning and in this instance, workforce development in noise engineering can be boosted. In the future, we hope to extend the applications to other concepts related to noise engineering.

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