Lessons Learned Teaching a Summer Bridge Program for Engineering Transfer Students in a Remote Environment

David W. Parent, *Member, IEEE*, Jinny Rhee, Elisa Parent, Alexander Shapiro, and Shifa Shaikh

Abstract— **In this work, which is intended to be a Work in Progress Paper in the Innovative Practice Category, the lessons learned from developing a unique summer program for transfer engineering students to help students make a successful transition from a community college to a four-year university are presented. This work is concerned with the research project that the students completed rather than the other aspects of student success that were presented during the summer program. This transfer student program could increase student success rates for any institution with a large transfer student population. While preliminary for students who completed the project results are promising, more needs to be done to increase the number of students who completed the project in the future.**

Keywords: Stochastic Resonance, Remote experiments, Student Success, Transfer students, ADALM2000

I. INTRODUCTION

IT has been well documented that transfer students face a unique set of issues during their first semester at the destination university compared to their non-transfer counterparts [1-2]. One successful intervention has been summer bridge programs [3-10], which have been especially effective in transitioning underrepresented minority students from a two-year institution to a four-year institution [11-14].

The summer bridge program at San Jose State University has been offered since 2013[3,4]. The traditional bridge program included a hands-on project conducted in a face-to-face environment. Students who had participated in the previous offering of the summer bridge program had a service learning-based project. The project teams consisted of ten transfer students. The team project solved a problem that a community member needed addressed. While service-learning projects are an excellent method of engaging underrepresented minorities, student feedback was that the students wanted an engineering project. In addition, the carpentry-based service-learning projects were not scalable to a large number of students. The service-learning projects were also resource-intensive in terms of time, as they could only be accomplished within a two-week residential environment. It was believed that an online engineering-based project could be scaled to attract more students to participate, even though pandemic-related health others forced the cancelation of the residential type summer bridge experience.

A research-based project for the summer of 2020 was chosen because working on a research project at a university closely mimics working in the industry. The only difference between a university research project and an industrial internship project is that new knowledge is created rather than new. The theory of situated Cognition (SC) [15] supports keeping the learning environment as close as possible to the situation in which the learning will be applied. SC has been applied to implementing problem-based learning [16], new Chemistry laboratory experiments [17], and online course development [18]. SC has been used in other research-based programs to increase student engagement. [19-22].

By participating in a student-centered, faculty-led research project, students will develop relationships with their peers and faculty to make the student feel more connected to the university, thus increasing the number of students who complete their degrees. Feeling connected should reduce student anxiety and thus the cognitive load students face. Given that Cognitive load theory [] states that the human mind has limited working memory and that cognitive overload reduces student learning and performance, treatments such as student participation in a research activity should decrease student cognitive load and thus increase student performance.

Another benefit to student participation in a research project is that by completing the project, skills would be developed that would lead to a student securing a technical internship.

II. METHODS

1) Project Overview

The project is part of a ten-day transfer student summer bridge program that includes a project but talks from professors about math competencies, advisors on how to succeed in college, and the advising staff on on-campus resources. There is a two-hour project session each day, including 30 minutes of theory and 90 minutes of project work. For the first five days, the students follow a self-paced tutorial where they learn how

All authors were with the Electrical Engineering Department of San Jose State University. Their respective email addresses were: David.Parent@sjsu.edu, Jinny.Rhee@sjsu.edu, Alexander.Shapiro@sjsu.edu, Elisa.Parent@sjsu.edu, and Shifa@Shaihk@sjsu.edu.

to be part of a research team by learning circuit simulation, fabrication, and test (described later). They also learn how to present results professionally using Python. Over two days, they learned the tools they used on the project and how to measure stochastic resonance in a circuit-based physical system over two days. After they are fully trained to be part of a research group, the students are formed into three two to three-person teams and assigned a TA to assist them. They are given two days to conduct their experiment and one day to prepare and present their results in an oral team presentation. 14 students completed the project, and three TAs helped supervise them. The TAs also helped during evening office hours so students could catch up or answer their questions. The following section will cover the details of the project.

2) **Stochastic Resonance Project Description:**

The research project consisted of replicating the study of an Operational Amplifier (OPAMP) configured as a stochastic resonator that was presented in a seminal work in the field of stochastic resonance [25]. A stochastic resonance (SR) system can amplify a weak signal by adding noise with a frequency range near the target signal's frequency [26]. SR was chosen for the summer bridge research project because SR is a research topic in all engineering areas [27-33]. In addition, the stochastic resonator circuit is relatively easy to build because it consists of only two resistors and an OPAMP configured as a Schmitt Trigger (Fig 1.). Schmitt triggers remove spurious transitions due to the hysteresis in the input/output relationship (Fig 2.). The hysteresis width is the sum of the two switching threshold voltages (negative threshold (V_{TN}) and positive threshold (V_{TP})), which are programmed by the output voltage maximum and minimum and two resistors R_1, and R_2. An SR-based resonator can be made from an inverting Schmitt trigger by replacing ground with a voltage source connected to R_1 (Fig. 3).

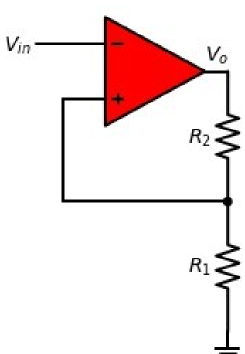

Fig 1: Inverting Schmitt Trigger, Power supplies (not shown ±5V, LT1630) R_2=100kΩ, R_1=10kΩ. OPAMP part#, LT1630.

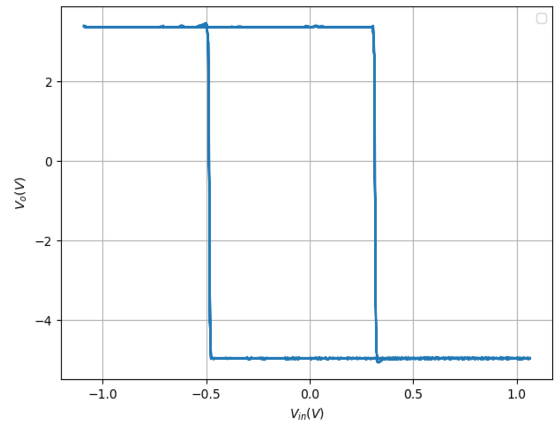

Fig 2: Plot showing the hysteresis width of an inverting Schmitt Trigger with switch thresholds of V_{TN}=-0.5 and V_{TP}=0.3V.

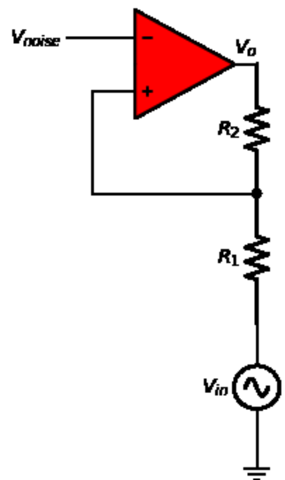

Fig 3: Schematic of an Inverting Schmitt trigger configured as a stochastic resonator.

Stochastic resonance occurs near the Kramers rate [34], which is the inverse of the full-width half maxim of the output of the Schmitt trigger when white noise (band-limited to 10kHz) is fed into the negative terminal of the Schmitt trigger, and the amplitude of the forcing function is set to zero. The full-width half maxim (FWHM) is evaluated by calculating the power spectral density of the output signal, curving this result with a Lorentzian distribution, from which the FWHM can be extracted. To test for stochastic resonance, a forcing function is applied between R_1 and ground (Fig 3.). To measure the signal-to-noise ratio, the power spectral density is calculated. Then the output peak with a forcing function is divided by the value of the Lorentzian distribution. The peak-to-peak voltage of the forcing function is chosen to be smaller than the hysteresis width to ensure the focusing functions cannot cause enough not to cause a transition with the addition of noise.

Students simulated the stochastic resonator in LTspice, which is Linear Technology's (LT) version of a simulation program with integrated circuit emphasis. The simulation time was one second using a schematic provided by the instructor. The resonator output and the Schmitt trigger were saved as .wav files sampled at 100kHz. Python was used to read the data and process the LTspice log file. After LTspice system modeling, the students built the Schmitt Trigger and measured the FWHM values as a function of the root mean square of the input noise.

3) **Summer Bridge Environment**

The only assumptions about student prerequisite knowledge are that the transfer students had passed at least one calculus course, one calculus-based physics course, a college-level oral communication course, and a college-level writing course. In addition, students were expected to have some programming knowledge. A lab manual that was essentially a self-paced tutorial that taught all the prerequisite technical skills required to complete the project was developed. The students learned circuit analysis with LTspice, data manipulation with Python, circuit construction with a breadboard, and circuit testing with the Analog Devices Active Learning Module (ADALM2000) kit [28]. The students were also introduced to working in a remote team environment using email and Zoom for communication, Google Sheets for project management, and Google Slides to present results.

The students who participated in this project were lower-division transfer students from local community colleges. The students were from all engineering majors, and there was no guarantee that the students had an introduction to circuit analysis or a programming course. Not all engineering students would have had an electronics lab course either. Given these constraints, the instruction assumed that the students only knew high-school-level electronics and calculus. Even if the students had had the prerequisite knowledge, starting from the basics was probably a good idea, given that the program's purpose is to welcome students to the college.

The three teaching assistants were junior and senior undergraduate and graduate students with experience using LTspice, Python, and test equipment. The teaching assistant (TA) training consisted of learning what stochastic resonance was and how to use LTspice, Python, and the ADALM2K analog testing kit. In addition, TAs were trained to help debug breadboard circuits remotely.

The classes and lab work were all done remotely using Zoom. Students were expected to have an internet connection that could support video conferencing and a PC that could run the software. Each student and TA were mailed a kit consisting of:

1. ADALM2K
2. Protoboard
3. 2 Red light-emitting diode (LED)s
4. Resistors: Two each of 100Ω, 10kΩ, and 100kΩ
5. Capacitors: Two each of 220nF and 2.2nF
6. 1 LT1630 OPAMP
7. Connection wires

The cost of the kit was $260.

A lab session was dedicated to helping the student install LTspice and Python on their local computer.

The number of students in each section was approximately five but should be able to be scaled to 15 students per section. The TA would then help the students with the task in the self-paced lab manual. To keep track of each student's progress and ensure no one was left behind, the lab manual had "TA checkpoints," in which the students showed the TA that they had completed a task from the lab manual. The TAs then placed a checkmark on a google sheet to track progress.

The lab manual was broken up into modules that could be completed in one or two sessions:

1. Introduction to signal generation using LTspice
2. Getting started with signal analysis (plotting) using Python
3. Getting Started with Circuit Analysis
   a. Circuit Elements (Resistor, Inductor (L), Capacitor)
   b. Series and parallel circuits
   c. Direct Current DC analysis
   d. Biasing an LED
4. Getting started prototyping circuits:
   a. through-hole parts, solderless breadboards, and ADLAM2K
5. Demonstrating Stochastic Resonance with a Schmitt trigger
6. Using a Schmitt trigger to conduct stochastic resonance research.

Once the students completed the training, they were given a group research task. This offering was to find the signal-to-noise ratio of the stochastic resonator at a fixed frequency and vary the root mean square (RMS) voltage of the noise (Θ). The groups' results were presented.

III. RESULTS AND DISCUSSION

The results are promising, given that out of 12 students who completed the project, only two are at risk for academic probation. Survey results indicate that the project was an essential part of the program, although many students indicated they would have liked to have the program face to face. Unfortunately, less than half of the students who signed up for the program completed the project. Out of 29 registered students, eight were a no-show, and nine did not finish the project. Preliminary data suggests that the students did not complete the program due to financial reasons.

Figures 4, 5, and 6 were created by students who completed the project and were part of their final oral presentation at the end of the program. Figure 4 is the protoboard implementation of an SR, while Figure 5 is the power spectrum of the output demonstrating SR. Figure 6 is the spectrum analyzer output of the ADALM2K showing an SR peak from the fabricated circuit.

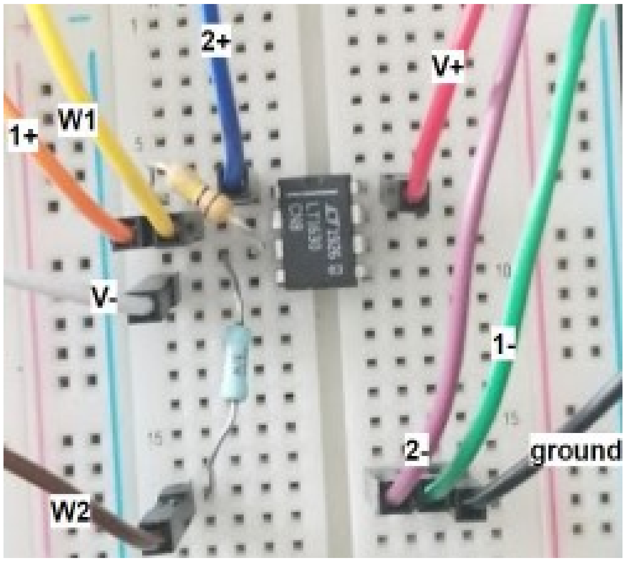

Fig 4: Protoboard implementation of the stochastic resonator (Schmitt Trigger).

t

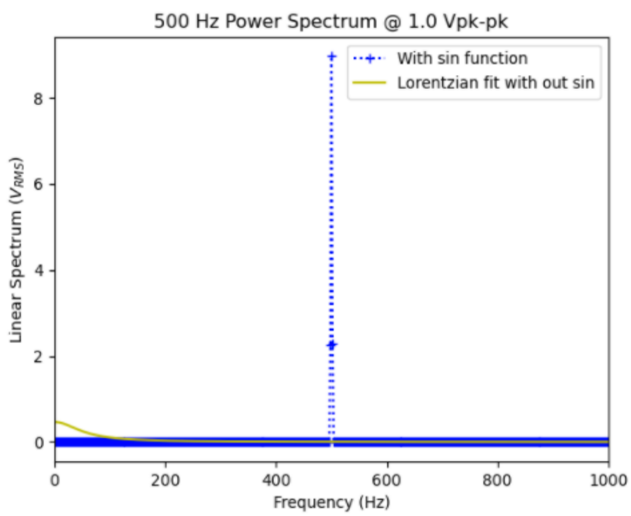

Fig 5: Power spectrum demonstrating stochastic resonance (Data generated by LTspice simulation.).

Fig. 6: Spectrum Analyzer results for stochastic resonator circuit, detecting the weak sin wave input.

1) **Transfer Student Survey:**

There were 14 questions on the overall improvement of Engineering aspects, Where SA=Strongly Agree, A=Agree, NAD=Neither Agree or Disagree, D=Disagree, and SD= Strongly Agree.

The EXCEED 2020 program has increased my:

1. confidence with math: SA=1, A=16, NAD=4, D=0, SD=0
2. awareness of math applications: SA=6, A=8, NAD=2, D=0, SD=1
3. confidence tackling projects: SA=7, A=4, NAD=3, D=0, SD=1
4. teamwork skills: SA=6, A=6, NAD=3, D=0, SD=1
5. career awareness: SA=9, A=4, NAD=1, D=0, SD=1
6. study skills for success: SA=6, A=8, NAD=2,
7. knowledge of university resources: SA=7, A=6, NAD=1, D=0, SD=1
8. navigation of college resources: SA=8, A=6, NAD=1, D=0, SD=1
9. understanding of diversity and equity: SA=7, A=8, NAD=1, D=0, SD=1
10. understanding of the importance of exercise to learning: SA=8, A=6, NAD=1, D=0, SD=1
11. social network: SA=6, A=10, NAD=1, D=0, SD=1
12. familiarity with Zoom: SA=10, A=0, NAD=2, D=0, SD=1
13. familiarity with Canvas: SA=9, A=2, NAD=2, D=0, SD=1
14. confidence in attending San Jose State University.: SA=9, A=6, NAD=0, D=0, SD=1

Where SA=Strongly Agree, A=Agree, NAD=Neither Agree or Disagree, D=Disagree, and SD= Strongly Agree.

Six more questions were asked about belonging:

These preliminary results are reasonable given that more than 50% of the students strongly agreed or agreed that the summer bridge program was effective at helping students understand how to succeed at San Jose State University. Almost all students felt the summer bridge program increased their confidence in attending SJSU.

Six more questions were asked about belonging:

1. I see myself as part of the engineering community at San Jose State University.: SA=11, A=4, NAD=0, D=0, SD=0
2. I feel that I am a member of the engineering community at San Jose State University.: SA=9, A=6, NAD=0, D=0, SD=0
3. I feel a sense of belonging to the engineering community at San Jose State University.: SA=9, A=6, NAD=0, D=0, SD=0
4. I feel like people at San Jose State University. like me.: SA=9, A=6, NAD=0, D=0, SD=0
5. I see myself as part of the campus community.: SA=6, A=10, NAD=0, D=0, SD=0
6. I feel that I am a member of the campus community.: SA=5, A=10, NAD=0, D=0, SD=0

These results strongly indicate that the summer bridge program helps students feel that they belong at San Jose State University.

The students could also fill out a section on what they thought could be improved. Many students felt that more time was needed to do the project. Some did not like that it was conducted online.

2) **TA 1's perspective on transfer students**

Motivating students to continue to attend each session seemed to be the most challenging part of the program. Although students had paid a small amount to help cover the equipment and motivate them to follow through with the program, some students never joined the program, and others dropped out of touch. Because our students balance school, work, caring for their family, and other responsibilities, it is difficult to tell whether the students who did don finish the program did so for personal reasons, the workload, or the subject of the work being done during the program.

The guided research project was difficult for students—although many students did not come from an electrical engineering background, the guides and instructions they provided helped them focus on their problem-solving and research abilities rather than their technical knowledge and skills. Students were pleased to see that meaningful research was possible in their studies. Especially for undergraduate students coming from high school, or in this case, community college, research is a "foreign area" that appears to be reserved for faculty and graduate students. Students may have had this feeling amplified because one starts with a practically blank slate when transferring schools, and the online modality was unproven. By making it clear from the beginning that any interested student can get involved in research, students can feel more comfortable approaching faculty and exploring their interests in their fields.

3) **TA 2's self-reflection**

As a TA, I became more comfortable myself working with faculty and my peers. Because I was a rising sophomore, I was concerned that I would not be qualified when it came time to lead a group of transfer students and teach them topics I did not know about just a few weeks before. I felt confident speaking to my department, and the college's administration and even asked to be introduced to other faculty. I have started my research, and it has supported my career more than I could have imagined. I forwarded the confidence teaching in the program gave me and the connections I made into finding an internship and came away with an excellent opportunity for the summer after my sophomore year. My research and work with faculty have expanded to include faculty at other schools and conference presentations. Perhaps even more so than the students I guided, being a TA for this program inspired me to take charge of my own education and make the best of the few years I have at school.

IV. CONCLUSION\

Given that the summer bridge program was favorably by received by the students who participated, the next issue that remains to be solved is to increase the number of students participating in the program and the number of students who can complete the project. The same project was used in the summer of 2021, but the completion rates did not significantly change. Given that students have to work on their own (even with TA help) to complete the project, this might be putting too significant a time burden on students who have to work. The online freshman project has much higher completion rates, and they only work two hours daily. Perhaps the SR project can be simplified. In addition, it is too expensive to spend hundreds of dollars on each student.

The students were able to participate in authentic research tasks. They were able to simulate and build a circuit and measure the results of an experiment. Their work has led to six research questions that can be answered in the following years:

1. How do the non-ideal parameters of an OPAMP such as gain bandwidth, open-loop gain, slew rate, and offset voltage affect resonator properties such as the barrier height, the full width half maximum frequency of the resonator with an input sin wave is proportional to
2. How does the hysteresis width affect the barrier height?
3. Can this be implemented digitally in a microcontroller?
4. Can this be implemented in a field-programmable analog array?
5. Assessment metrics and rubrics need to be developed following [29].
6. Projects from other fields need to be included as face-to-face project work becomes realistic.

Another positive outcome was that students who completed the project all had all found internships to enhance their career development. The negative outcome is that they were not available to be TA's

REFERENCES

[1] P R.M. Fauria and M.B. Fuller, "Transfer student success: Educationally purposeful activities predictive of undergraduate GPA." *Research & Practice in Assessment*, vol. 10, pp. 39-52 2015.

[2] C. Maliszewski Lukszo and S. Hayes, "Facilitating transfer student success: Exploring sources of transfer student capital," *Community College Review*, vol. 48, no. 1, pp. 31-54 2020.

[3] S.H. Gleixner, "EXCEED: Excellence in your engineering education summer transition program," *Age*, vol. 23, pp. 1 2013.

[4] M. Mayol, "Bridges to college success: Latino's in the MESA program at SJSU," 1999.

[5] C.B. PIERRE and D. MATHIAS, "Statistical process control and cooperative learning structures: A data assessment and improvement system used in a san Jose state university summer bridge programme," *European Journal of Engineering Education*, vol. 20, no. 3, pp. 377-384 1995.

[6] N. Salzman, A. Delaney, C.R. Bates and D.C. Llewellyn, "Easing Students' Transitions to University Via a Summer Bridge and Outdoor Experience Program," in *2019 ASEE Annual Conference & Exposition*, 2019.

[7] K.M. Cooper, M. Ashley and S.E. Brownell, "A bridge to active learning: A summer bridge program helps students maximize their active-learning experiences and the active-learning experiences of others," *CBE—Life Sciences Education*, vol. 16, no. 1, pp. ar17 2017.

[8] B. Bir and M. Myrick, "Summer bridge's effects on college student success," *Journal of Developmental Education*, pp. 22-30 2015.

[9] N.L. Cabrera, D.D. Miner and J.F. Milem, "Can a summer bridge program impact first-year persistence and performance?: A case study of the new start summer program," *Research in Higher Education*, vol. 54, no. 5, pp. 481-498 2013.

[10] T.J. Grites and A. Farina, "Enhancing transfer student success: The transfer seminar," *Teacher-Scholar: The Journal of the State Comprehensive University*, vol. 4, no. 1, pp. 2 2012.

[11] C.B. Newman, "Corporate internships, undergraduate research, and finances: Successful African American engineers' consideration of immediate workforce entry or graduate school," *Journal of STEM Education: Innovations and Research*, vol. 21, no. 1 2020.

[12] S.P. Ackermann, "The benefits of summer bridge programs for underrepresented and low-income transfer students," *Community/Junior College Quarterly of Research and Practice*, vol. 15, no. 2, pp. 211-224 1991.

[13] A. Gonzalez Quiroz and N.R. Garza, "Focus on student success: Components for effective summer bridge programs," *Journal of Hispanic Higher Education*, vol. 17, no. 2, pp. 101-111 2018.

[14] J. Slade, D. Eatmon, K. Staley and K.G. Dixon, "Getting into the pipeline: Summer bridge as a pathway to college success," *The Journal of Negro Education*, vol. 84, no. 2, pp. 125-138 2015.

[15] J. Brown, A. Collins, P. Duguid, "Situated cognition and the culture of learning.", Educational researcher. 1989 Jan;18(1):32-42.

[16] D. Hung, "Situated cognition and problem-based learning: Implications for learning and instruction with technology.", Journal of Interactive Learning Research. 2002;13(4):393-414.

[17] E. Kelley, "LAB theory, HLAB pedagogy, and review of laboratory learning in chemistry during the COVID-19 pandemic.", Journal of Chemical Education. 2021 Jul 13;98(8):2496-517.

[18] L. Archambault, H. Leary, K. Rice, "Pillars of online pedagogy: A framework for teaching in online learning environments.", Educational Psychologist. 2022 Jun 6:1-4.

[19] S.H. Russell, M.P. Hancock and J. McCullough, "Benefits of undergraduate research experiences," 2007.

[20] D.J. Brook, "Keys To Building and Maintaining a Successful Undergraduate Research Program: Designing Research Projects for an Undergraduate Research Lab," in *Developing and Maintaining a Successful Undergraduate Research Program,* Anonymous: ACS Publications, 2013, pp. 51-59.

[21] S.H. Russell, M.P. Hancock and J. McCullough, "Benefits of undergraduate research experiences," 2007.

[22] D.J. Brook, "Keys To Building and Maintaining a Successful Undergraduate Research Program: Designing Research Projects for an Undergraduate Research Lab," in *Developing and Maintaining a Successful Undergraduate Research Program,* Anonymous: ACS Publications, 2013, pp. 51-59.

[23] P. Chandler, J. Sweller, "Cognitive load theory and the format of instruction", Cognition and instruction.,1991 Dec 1;8(4):293-332

[24] A. Skulmowski, K. Xu, "Understanding cognitive load in digital and online learning: A new perspective on extraneous cognitive load.", Educational psychology review. 2021 Jun 28:1-26.

[25] S. Fauve and F. Heslop, *"Stochastic resonance in a bistable system,"* Physics Letters A, 97, 5-7 (1983).

[26] L. Gammaitoni, P. Hänggi, P. Jung and F. Marchesoni, *"Stochastic resonance,"* Reviews of Modern Physics, 70, 223 (1998).

[27] M.D. McDonnell and D. Abbott, *"What is stochastic resonance? definitions, misconceptions, debates, and its relevance to biology,"* PLoS Comput Biol, 5, e1000348 (2009).

[28] A. Elhattab, N. Uddin and E. OBrien, *"Drive-by bridge frequency identification under operational roadway speeds employing frequency-independent underdamped pinning stochastic resonance (FI-UPSR),"* Sensors, 18, 4207 (2018).

[29] Y. Lei, J. Lin, D. Han and Z. He, *"An enhanced stochastic resonance method for weak feature extraction from vibration signals in bearing fault detection,"* Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 228, 815-827 (2014).

[30] J. Li, X. Chen and Z. He, *"Multi-stable stochastic resonance and its application research on mechanical fault diagnosis,"* Journal of Sound and Vibration, 332, 5999-6015 (2013).

[31] A. Dodda, A. Oberoi, A. Sebastian, T.H. Choudhury, J.M. Redwing and S. Das, *"Stochastic resonance in MoS 2 photodetector,"* Nature Communications, 11, 1-11 (2020).

[32] W. Fink, *"Stochastic Optimization Framework (SOF) for Computer-Optimized Design, Engineering, and Performance of Multi-Dimensional Systems and Processes,"* Space Exploration Technologies, 2008, pp. 69600N.

[33] S. Mitaim and B. Kosko, *"Adaptive stochastic resonance,"* Proceedings of the IEEE, 86, 2152-2183 (1998).

[34] H.A. Kramers, *"Brownian motion in a field of force and the diffusion model of chemical reactions,"* Physica, 7, 284-304 (1940).

[35] "ADALM2000 Overview," *ADALM2000 Overview [Analog Devices Wiki]*, 17-Mar-2021. [Online]. Available: https://wiki.analog.com/university/tools/m2k. [Accessed: 13-May-2021].

[36] Khoukhi A. A structured approach to honours undergraduate research course, evaluation rubrics, and assessment. Journal of Science Education and Technology. 2013 Oct;22(5):630-50.