Tom and Carol Williams Fund for Undergraduate Education

Williams Instructional Proposal Application

Submission of a **Williams Instructional Proposal** requires short paragraph responses to the prompts below. The prompts are related to a description of the project, its significance, how you will evaluate the success of the project, the budget or resources needed, and the lasting impact of the project.

Please submit a completed version of this document to OtP@uoregon.edu.

Please write your answers to each of the questions below

Demographic Information

Your name: **Christina M Karns**
Your email address:
Your department(s) or unit(s):
Psychology
CBIRT: Center on Brain Injury Research and Training
Your title: **Sr Instructor I, Psychology**
Assistant Research Professor, CBIRT
Proposal title: **Hands on STEM: Brain Biosensing**

Williams Instructional Proposal Application

1. Provide a brief overview of the project you're proposing:

Research on instructional design for STEM (Science Technology Engineering and Math) is clear that hands-on learning is critical for students to build the mental models necessary to innovate in scientific research, business, or industry. Hands-on learning in STEM also supports knowledge-building in non-STEM fields (such as Education) that rely on hypothesis-testing and the scientific method to construct evidence-based practices. However, there are many barriers to involving students in hands-on research at a large R1 research university like UO. These barriers include COST, SCALABILITY, and availability of SCAFFOLDING materials. This proposal will capitalize on recent technical innovations to create a hands-on course Psychology or Neuroscience, "DIY Brainwaves" where students assemble a neurophysiological recording apparatus for brainwave recordings (electroencephalography/EEG), conduct recordings, and perform basic analyses using a low-cost open-source technology that has been developed in recent years (OpenBCI).

Phase I - Pilot: In phase 1, a pilot lab-based course would be conduced with 19-25 students who would work in groups of 3-5 students to develop digital training manuals (E-portfolios) that document their progress in meeting the learning objectives outlined below:

By the end of the Phase I course, students will be able to:
- Explain neurotransmission and how the excitatory and inhibitory post-synaptic potentials that are measured at the scalp with EEG
- Use electrodes to digitize and record the amplitude (voltage) of EEG in the time domain
- Convert voltage x time recordings to the frequency domain (Hertz) using power spectral densities
- Explain how signal to noise limitations are addressed by scaling up sample sizes
- Propose feasible applications of EEG to characterize different brain states or to develop brain-computer interfaces.

'Deliverables' would be instructional content harvested from student work in the pilot course to scale-up the project to a larger course in a subsequent term.

1. Student E-portfolios (videos, slides, posters of methods and project outcomes)
2. Online open database of de-identified student-collected EEG data
3. Design and analysis ideas generated from in-class discussions

Phase II – Large Enrollment Course (~50 – 100 students)
The larger course would scale-back (but not eliminate) small-group instructor-supported lab activities. Students would view videos and materials curated from Phase I's E-portfolios for a 'flipped classroom' approach. The larger course would focus more strongly on the analysis and application learning objectives. (Think of a cooking show, where most of the ingredients are already mostly prepped ahead of time, but the final dish has not yet been assembled.) Ideally, students who were successful in the pilot course could be recruited as paid facilitators for the larger-enrollment course (if that project component is funded) or otherwise receive practicum course-credit for their instructional support.

At the end of the Phase II course a new cohort of students would be able to:
- Describe neurotransmission and the excitatory and inhibitory post-synaptic potentials that are measured at the scalp with EEG
- Record EEG and contribute to open-source data repositories
- Transform EEG from the time domain to the frequency domain.
- Demonstrate the importance of addressing signal-to-noise limitations through artifact identification and scaling-up sample sizes
- Propose approaches to distinguish between two brain states
- Propose potential applications (such as a brain-computer interfaces, diagnostic tools, or hypothesis testing).

Project Significance

2. Why is the project worth trying? What issues or gaps would this project resolve? What opportunities would it explore?

There are significant barriers to providing hands-on STEM instruction, particularly in human Neuroscience and Psychology. These barriers include **cost**, **scalability**, and availability of **scaffolding** materials. This project intends to capitalize on recent innovations to provide a sustainable model for multidisciplinary instruction in human brain electrophysiology. Non-invasive human electrophysiology such as EEG has many exciting applications such as brain-computer interfaces for disabilities (such as ALS), novel human computer interfaces for gaming, or potentially to integrate with virtual/augmented reality.

COST: Through a fortunate convergence of recent developments in technology, EEG has never been so accessible. Developments in hobby electronics (e.g. Arduino boards, 3-D printers) have coincided with a movement toward open-source and open-access hardware and software development (e.g. Github, Python, R) have made EEG recording and analysis more accessible and affordable. Although high-cost research-grade equipment is still preferred for most scientific applications there are also lower cost options used in research. I recently built a wireless 16-channel OpenBCI EEG recording system for less than $5000 and have been impressed with the results. OpenBCI has an instructional bundle that includes five 4-channel EEG recording devices for $4600. This is enough to support one class of 25 (with 5 students per group). With two instructional bundles ($9200), one class of 50 could be supported (with 5 students per group) or group sizes could be reduced to 3 in a smaller class. The instructional OpenBCI system is highly portable and recording software is supported on most Mac and PC laptops that students already use day to day.

SCALABILITY: Students and faculty now have an impressive array of technology available at their fingertips: Iphones can record cinema-quality video. Video-editing software such as Panopto is already integrated into learning platforms like Canvas. Computers are more powerful at lower cost. The accessibility of augmented or virtual reality devices is rapidly increasing. These innovations allow us to design and build a course that engages students in creating digital instructional materials.

SCAFFOLDED MATERIALS: I bring my extensive expertise with conducting EEG research and training undergraduates in formal data-collection for experiments. Today, because of the positive movement toward open-science, there are also several excellent open-source resources for teaching basic EEG methods and conceptual underpinnings that I can build on to support student learning (e.g. ERPLAB Bootcamp, UCONN Brainwaves, or PURSUE). There are also open-source repositories of EEG data that can be used to support students (OpenBCI datasets) which could prove useful for students who are not successful in recording their own data. (Things can go wrong in science, but we still learn from those failures!)

3. How could this project improve the educational experience of undergraduates?

Rather than an abstract sense of how human brain data can be used to understand the brain or create brain-computer interfaces, students will have a direct experience with recording and using their own brainwave data. Hands on, group-based learning with real-world applications are key strategies outlined in High Impact Practices (aacu.org/leap/hips). Students will contribute real data to an online repository that will be posted to the OpenBCI community as a resource that others can use. Students will develop their technical writing and instruction skills through creating E-potfolios that demonstrate their skills for future opportunities (jobs, graduate school, internships, etc) – tools that can be used to support instruction in a scaled-up version of the course.

4. How does this proposal create a more inclusive teaching and learning culture on campus? For example, proposals might support student learning about difference, inequality, and agency or seek to enhance the social and emotional climate of the classroom.

Group work facilitates inclusive culture, making connections between students, and capitalizing on individual student strengths, which can be difficult at a large university. Representation of diverse identities in STEM is also important. The course will be lead by me (a woman in STEM, Ph.D. in Neuroscience, first in my family to attend a 4-year university). There will also be "cameo appearances" (faculty guest speakers) who will visit the course to talk about how they use EEG in their research. These will include Dr. Nicki Swann (Asst Prof Human Physiology) and Dr. Rachel Weissler (Asst Prof Linguistics) both of whose identities are also underrepresented in STEM and who are excited to contribute.

5. How many undergraduate students would be directly affected?

Because this project requires specialized equipment, the number of students will scale with the amount of investment in the project. At the lower end, the 25 undergraduates students in the Phase I course would be directly affected. At the higher end of investment, 125 undergraduate students per year would be directly impacted (25 pilot + 100 scaled-up). The published repository of data could also be used for independent student research projects in psychology, neuroscience, human physiology, data science, or bioengineering topics.

At this stage, I am envisioning the pilot course as an upper-division course. As the materials and curriculum are vetted, the project could be moved to the 200 level course potentially for the honors college (where I currently teach a 200-level science seminar that started as a 400-level seminar). I am open to further discussion about how to build a coure that would best serve UO student needs in the long run.

6. Does the project have implications for teaching and learning that extend beyond a single course or discipline? Are there aspects of this project that encourage students to make connections to areas of thought and experience beyond the context of a single course?

This project has many multidisciplinary implications. For example, although the course would likely be initially offered as a Psychology course (my home instructional department), Cognitive neuroscience is an interdisciplinary field, drawing on psychology, neurobiology, human physiology, engineering, linguistics, mathematics, and computer science. Faculty cameos from other EEG-researchers Dr. Nicki Swann (Human Phys) and Dr. Rachel Weissler (Linguistics) will seed connections to other disciplines. In addition, Dr. Nicole Dudevic, director of the Neuroscience program, is enthusiastic about this course and its relevance to students in her program. In psychology, there is often high demand for brain-based courses relevant to undergraduate research. This course would provide a high-throughput introduction to one of the main non-invasive methodologies of human neuroimaging. The PSC Reality Augmentation and Virtual Experiences Lab (RAVE Lab) in the Knight Library could be used to support student generated research and applications. Over the long term, I am also excited to explore potential collaborations with new undergrad and grad programs in immersive media (such the Master's Degree in Immersive Media Communication and the Oregon Reality Lab UO Portland), UO's data-sciences program, and or with bioengineering. This project could also be developed into a larger multidisciplinary NSF grant for undergraduate STEM education.

7. We recognize that it is within the typical job expectations for faculty to design new courses or update current courses, and for the department to support regular curriculum changes. Based on this, how is the project you are proposing unique or in need of Williams Council funds to happen?

To my knowledge, there is no course similar course offered at UO. Furthermore, this lab to classroom model could provide a template for other hands on instruction. Further, deliverables would be disseminated along with open-science objectives (instructional materials and open-source data).

Assessment/ Evaluation

8. Based on the specific problem you will address with this project, how and when will you assess whether or not you were successful? Will you include a pre-experience/post-experience assessment tool? Will you survey participants? What are your intended outcomes, and how will you measure your degree of success in meeting those outcomes?

I use backward design in my course development. The tentative learning objectives are outlined in the first section of this proposal. During development, each learning objective will be broken into steps and aligned with in-class activities, summative assessments, formative assessments, and the 'deliverables.'

Ongoing informal feedback on the course will be supported with weekly anonymous surveys, and one-minute papers so I can track engagement, learning, and the success of group work.

Budget/Resources

The Williams Council has set a common stipend of $1000+33%OPE per faculty per week for any summer work included. When summer course development is requested, we gravitate toward a two-week standard and go above that—typically to four—when faculty advocate for this need. The common stipend for guest speaker travel and hosting is $2000. Please use these amounts when building your budget, if relevant. Please also consider that last year's funded proposals ranged from $5,230 to $17,760, although any amount can be proposed up to the approximate $100,000 available.

9. What amount of financial support from the Williams Council would make this project possible, and for what purposes would the funding be used (e.g. travel, equipment, staff support etc.)? It should be clear that the funding requested goes beyond summer stipends for course preparation. If you are asking for funds to purchase equipment, please inquire into the availability of existing campus resources.

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10. Are you seeking additional financial support or resources for this proposal? If so, please describe.

I do not currently have other proposals for this project pending. However, I'm envisioning this could be developed into a comprehensive, multidisciplinary, NSF proposal focused on undergraduate education in Psychology/Neuroscience/STEM.

Lasting Impact

11. If this project proves successful, how could you foresee its continuation and persisting impact after the period of the Williams Council funding?

- The equipment is reusable and although it may require occasional low-cost part replacement or repair, it can be used for subsequent courses with minimal upkeep costs.
- I am designing this course as one that would be ongoing, taught once or twice per year, offering a hands-on learning experience to new cohorts of students.
- Data will be archived in a repository supported by UOLibraries with links posted to community collections such as OpenBCI and GitHub.
- Instructional materials could be developed into an online educational resource (OER).
- I would like to present the project at the annual Society for Neuroscience meeting in section on undergraduate education, collaborate on a press release about the project, and publish a peer-reviewed article about the teaching process and online data repository.