NRI: Co-Robots to Enhance Motivation and Self-efficacy in Formal STEM Education

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Abstract

The aging population will double by 2050 and there won't be enough healthcare professionals. In order to evolve healthcare technologies to meet the demands, we must engage young people in assistive and rehabilitation co-robotics learning experiences early in their education. To accomplish this, we use an engineering technology curriculum utilizing the Neupulator (a co-robot) to conduct professional development (PD) sessions for teachers in Indiana and Georgia. This project aims to increase STEM participation of underrepresented ethnical/racial minorities and female learners by increasing engineering self-efficacy, motivation, and performance in the completion of this curriculum. Preliminary quantitative survey results show 11.3% (p = 0.003) increase in engineering-related self-efficacy, and 15.5% (p < .001) increase in experimental self-efficacy. The research team conducted a PD session with 8 teachers (7 in Indiana and 1 Georgia) in Fall 2022. Following the PD, teachers were handed the curriculum (in the form of a website hosting the lesson plans and 15 Neupulator kits) and started implementing in Fall 2022 and Spring 2023. Furthermore, the team conducted a PD with 17 teachers in Georgia in Spring 2023 (March 30, 2023).

Objectives

1. **Continuously optimize** the **curriculum** by gathering feedback from **PDs and classroom implementations.**
2. **Empower teachers, with a diverse group of students,** through Professional development sessions.
3. Provide teachers with curriculum to implement in their **Foundations of Technology (FoT)** grade 9-11 classrooms.
4. Collect pre and post motivation, self-efficacy and learning data points from students, to answer the question; **Do co-robotics lessons significantly improve students' motivation, self-efficacy, and learning?**

The Neupulator

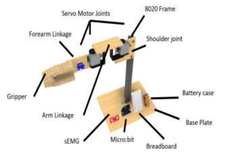
The Neu-pulator (neural manipulator) is a robotic arm that measures muscle voltage signals to control movement of revolute servo joints. The muscle activity is measured safely from the surface of the skin, through a technique called electromyography (EMG). These technologies are widely used in medical devices, prosthesis and co-robots. Yet, we propose an accessible, simplified and affordable version of these technologies to a formal classroom environment.

The team designed a curriculum (consisting of 10 lesson plans and a Neupulator kit). Lesson plans are centered on an assistive technology design challenge. The Neupulator kit costs less than 85 USD, curriculum is designed for students to work in pairs. After each professional development session and classroom implementation, the curriculum is iteratively redesigned to best suit the needs of the classroom.

Iterative Design

Neupulator assembled with handmade wooden pieces. Kit cost = 100 USD

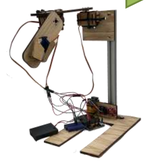
V1



Neupulator assembled with laser cut wooden pieces. Kit cost = 120 USD (supply chain difficulties)

V2

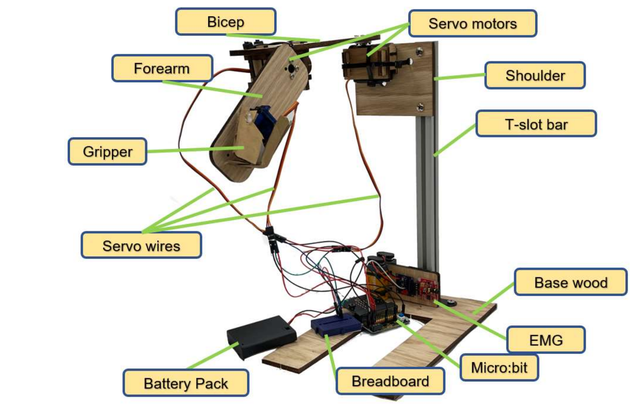
Curriculum showcased at ITEEA 2022 conference, gathering significant interest from educators and roboticists



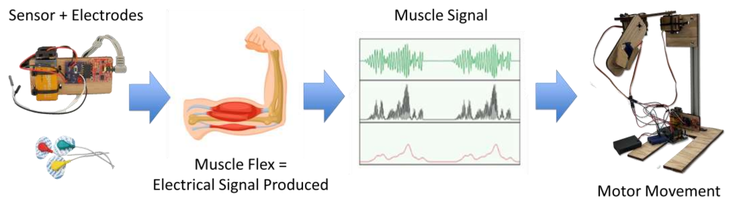
Current Neupulator design, eliminating screws using interlocking modular pieces. Reducing need for fine motor skills. **Kit cost = 80 USD**

V3

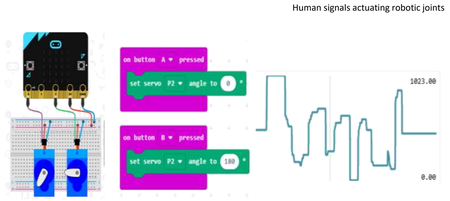
The Neupulator Curriculum



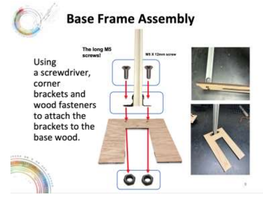
The Neupulator robot components



Human signals actuating robotic joints



Makecode programming environment



Sample lesson plan slide

Future Research

1. Analyze students' motivation, self-efficacy, and learning surveys to study effect of Neupulator curriculum.
2. Supply at least 10 Georgia teachers with the Neupulator curriculum.
3. Run a comparative study between the Neupulator curriculum and existing Engineering by Design (EbD) curriculum.

Professional Developments

The team conducted two major professional development sessions in Fall 2022 and Spring 2023. The sessions were extremely engaging and gathered significant interest from teachers. All participating teachers in the Fall 2022 PD ended up implementing the curriculum in their classes. Teachers participating in Spring 2023 PD are currently going through post PD survey to finalize their participation in the research study. PD sessions were conducted as a full day workshop (9 am – 4 pm), where teachers were introduced the project, then went through a hands-on session to build their own Neupulator. All PD sessions were followed by a "Homework", to make sure teachers fully understood the curriculum and were able to replicate results on their own.

Fall 2022 PD

Teachers building their own Neupulator as they go through the lesson plans

PI Nina Mahmoudian introducing the project during PD

Spring 2023 PD

Teachers working through the curriculum to build their own Neupulator robot

Broader Impact

On Education and Outreach – In Fall 2022 and Spring 2023, over 250 students already experienced building and controlling the Neupulator in their school. They have learned about assistive technologies and collaborative robotics, while also covering requisite teaching standards.

On Society – Teachers participating in this study have a diverse set of students, hopefully empowering students to pursue STEM careers focused on improving quality of life.

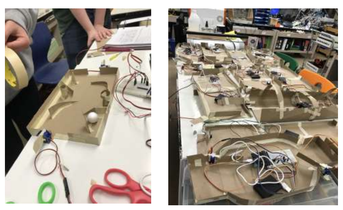
Potential impact – In Fall 2023 implementation, over 600 students, across 20 teachers in the state of Indiana and Georgia would have studied the Neupulator curriculum.

Lessons Learned

Too much vs Too little – Some teachers like extra detailed instructions that they can instantly hand off to students to use, others like reduced instructions to allow students space to shine. It's all about finding the perfect balance.

Research team pinball activity design – example of Too detailed instructions

Vs



Example of perfect balance of instructions and student creativity – students produced 10 different designs of a pinball board + students produced more engaging designs.

Supply Chain Problem/Opportunities – The EMG sensor used on previous versions of the Neupulator went out of stock. We modified an alternate sensor, manufactured our own printed circuit boards and reduced EMG related costs by half.

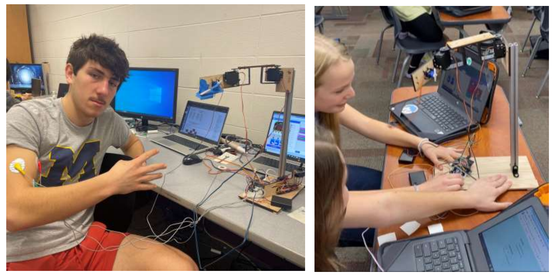
Industry Standard Consistency – Teachers have limited time to learn and master new lessons; we must provide easy to troubleshoot components by adhering to industry standards.

Outcome Empowerment – Final projects should be highlighting the technology at its best, success should be clearly defined, and obtainable. Student creativity will do the rest!

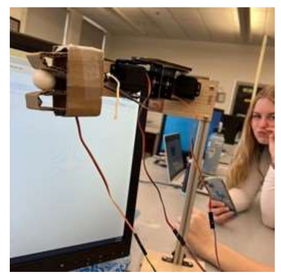
Teacher Professional Development

Students investigating Bio-Signals

Arm and Motor Assembly



End-Effector Design



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