Developing an Educational Robotic Platform
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**Introduction**

The proposed research project will continue my work in Dr. Aukes' lab over the past two semesters with the goal of demonstrating that a robot can be designed and built by and for undergraduate and high school students as an educational tool. Dr. Aukes' IDEALab utilizes laminate construction to build foldable robots from cheap materials, allowing robots—such as the one I will develop through this research—to be constructed from scratch in a matter of hours by students using readily-available equipment. The resulting platform and the methods used to make it will be publicly available and designed for use by instructors in teaching robotic concepts to students.

**Curiosity**

Working for a small company that sought to build robotics programs by working directly with educators at local elementary schools gave me first-hand experience seeing the challenges inhibiting the introduction of robotics into education. This research employs curiosity to ask the question of whether robots could be simple enough to be designed and built by undergraduate and high school students from scratch. As shown by the explosive growth of educational robotics competitions such as FRC and VRC, STEM education is on the rise, and many educators are looking to introduce engineering at younger ages, hence the introduction of newer competitions designed for younger ages such as FLL and VEX IQ which spawned from older competitions targeting high school students. If a system for designing and building low-cost robots could be developed, then students could use this system to design and build robots of their own from scratch. This approach allows students to fully experience the design process for themselves rather than relying on a kit in which much of the work has already been done for them. While many robotics kits targeting education are currently on the market, most are either preassembled and only teach programming (such as Dash by Wonder Workshop) or come as a set of parts from which the user can only build a predefined robot (such as Lynxmotion's robotic arm). The few kits that do allow for multiple designs to be built and programmed, such as LEGO Mindstorms and VEX EDR, cost hundreds of dollars per robot and are still limited in what can be made due to the use of proprietary parts and electronics. By building from scratch, students can set their own design goals and freely explore the possibilities rather than working within the confines of a kit.

**Connections**

One solution to the problem of making robots cheap and simple enough for students to build is laminate construction. Foldable robots are constructed from cheap planar materials that are laser-cut into a desired shape and then laminated together into the finished device. I have been working in Dr. Aukes' lab building foldable laminate robots for the past two semesters, developing force-sensing and simulation solutions for foldable robots. My research will bring together this prior work as well as the mentorship of Dr. Aukes to develop an educational robot using laminate materials. The outcome will directly connect with students and educators through the class EGR 598 Foldable Robotics being taught at ASU next semester. In this class, students will be constructing their own robots in a semester-long project while going through the same process of design, modeling, simulation, and experimentation that I am going through. By sharing my modeling and simulation files with the class, and by presenting a tutorial before the class, my work will be used as examples as the students develop their own robots. Although this is a 500-level course reaching primarily masters students, two of the 17 students enrolled are undergrads. It also is beneficial to begin by teaching higher-level students with more experience who will learn these concepts more readily and then work down to younger students as methods become perfected and as their efficacy is proven. Furthermore, I am currently working towards publishing a conference paper about my research for the spring semester. By publishing my work in an international conference, it will be seen by a variety of educators who can then utilize these techniques in their own classes. Moreover, the model and design files accompanying the paper can be directly used as examples from which students can build their own robots.

**Creating Value**

The tools and methods developed as part of this work, in addition to the robot itself, will increase educators' and students' accessibility to robotics. By replacing expensive and proprietary kits with readily available materials and open methods, more students, especially those living in underprivileged communities, can be introduced to engineering. This will benefit educators in high schools who are looking for ways to introduce engineering to their students in an engaging way but cannot afford to buy kits for an entire class. This will benefit younger students by deepening their exposure to engineering and providing an activity to pique the interest of potential young engineers. For undergrads, this work will result in an alternative to the limits of kits in which much of the work has already been done for students and will provide an opportunity to build and program a robot from scratch. It will allow them to gain a more in-depth understanding of their design and prepare students for industry experiences where they will be making products by incorporating diverse materials and parts from a variety of sources.