PROJECT SUMMARY

Overview:

Rapid adoption of electronic systems in both consumer and critical application space has closely linked the functionality of a system with the underlying hardware. The design and physical implementation of a system are generally hidden from the general users with the help of simplified, often attractive, casing and user-friendly software interface. This leaves the consumers vulnerable to reliability, security, and safety issues that stem from the hardware. Growing use of electronics in nearly all spheres of life has created a great need for engineers, scientists, and technicians to contribute to their sophisticated design and manufacturing process. However, misconceptions surrounding manufacturing jobs, along with the rising popularity of jobs in analytics and artificial intelligence motivate students with engineering majors to avoid hardware-related courses. While training in software, specifically in programming and coding, has received significant emphasis at both high school (HS) and UG level, knowledge of electronic hardware, i.e., the innards of a computer system – from bits to circuits to systems – and basic principles of their operation have not received much attention. It has contributed to a remarkable skill gap in the current electronics industry. Hence, there is a critical need for training early UG students to: i) teach the fundamentals of hardware from a system perspective through a hands-on approach, ii) stimulate their interest in hardware. To address this need, this project aims to develop a set of games played on an easy-to-use hardware platform to understand and practically implement the key concepts of hardware that are essential to modern computing systems. We aim to offer these games as an elective undergraduate course for all engineering majors in two institutions and also research and evaluate the feasibility of leveraging the games for high school students.

Intellectual Merit:

The project aims at investigating a new paradigm of training UG students on foundational concepts of electronic hardware and educating them on the key principles of system operation, including the underlying physics (e.g., signal propagation, switching of transistors) and mathematics (e.g., bits, Boolean algebra, logic gates) of computing, through a suite of well-crafted games, called PICABOO. Each game, to be played individually or collaboratively in a team, targets training students on one major concept of hardware using an engaging, experiential learning approach. The games in PICABOO will use an adapted version of a configurable and flexible hardware platform, called HaHa, developed by the PIs, through a recently-completed NSF project on hardware security education. The modification of the hardware platform will be performed to cover wide variety of hardware topics and to make the games more engaging (e.g., through integration of a multi-color led display). The project will address the following research questions. To what extent does PICABOO stimulate situational interest and learning of hardware security content among diverse groups of students including women, low socio-economic status students, first-time-in-college students and historically underrepresented ethnic minorities? The hands-on, minds-on training of electronic hardware will be offered to UG engineering students (primarily, in computer science and electrical engineering) as an elective course. The project will also develop a version of select games targeting HS students through the SSTP program. It will build on broad and complementary expertise of the PIs on developing educational technology and curriculum for UG and HS students.

Broader Impacts:

The games will educate a wide-range of students from different majors on the fundamentals of modern computing hardware that will help them to understand and handle the constantly arising safety and security issues related to their everyday devices. The games will help students to quickly adopt emerging technologies with more complex functionality, such as augmented and virtual reality. It will broaden participation and help create a skillful and diversified workforce in the semiconductor industry to reduce the current shortage of skilled candidates. This effort will also develop similar games for high-school students, attracting more students in pursuing electrical/computer engineering and help to address the skill gap further. The project will also increase the number of teachers capable of providing hands-on hardware training at the high-school level, creating a community that can advance the training methods and contents further. The games, hardware platform design, course materials, instruction guidelines, and other outcomes will be shared with the educational and semiconductor community through web portals, workshops, tutorials, and special sessions.