Project Summary

CAREER: WE FEEL SCIENCE: We Engage with the Flexible, Experimental Environment for Learning in SCIENCE

There is clearly a major challenge with getting people into the STEM fields and people with disabilities are underutilized in the U.S. The Individuals with Disabilities Education Act (IDEA) Amendments of 1997 require that students with disabilities receive full access to the general education curriculum. However, students with disabilities are often not adequately accommodated in science instruction. Science learning poses challenges to both sighted and visually impaired students: the abstractness of scientific concepts not related to one’s previous knowledge and sensory experience; the overwhelming mass of visual material. In particular, there have been few sensory-based learning support systems for visual impaired students to work together with their classmates, teachers or even with sighted peers in science lessons.

This CAREER proposal addresses these two educational challenges - STEM shortages and lack of access for those with disabilities. More specifically, the PI will design, evaluate, and implement WE FEEL SCIENCE, a haptically enhanced learning-by-collaborating system that allows students with and without visual impairments collaborative hands-on practices in science lessons through multiple, realistic and compatible sensory feedback (i.e., haptic, visual, and auditory). There are four components to this career development plan.

First, the PI will develop collaborative haptic interaction techniques that can support joint efforts (1) between the two sighted users and (2) between the two visually impaired users through haptic, visual, and auditory feedback. The PI will also systematically evaluate the overall quality of the techniques in order to obtain usability and performance data.

Second, the PI will refine a high-level software toolkit prototype, Design for Co-Touch, which can support the rapid prototyping and implementation of collaborative haptic learning applications. Four haptically enhanced learning-by-collaborating applications will be developed, in which a pair of (1) sighted students, (2) visually impaired students, (3) a sighted student and a sighted teacher, and (4) a visually impaired student and a sighted teacher can gain hands-on experiences with science concepts.

Third, the PI will formatively evaluate the applications (objective 2) to identify and improve existing weaknesses before use by users. The PI will also examine the cognitive (learning performance and attitude toward science learning) and affective (motivation) impacts of shared haptic experiences in the WE FEEL SCIENCE system on science learning of students with and without visual impairments.

Finally, students’ science learning will be supported by incorporating WE FEEL SCIENCE into their classrooms or labs. The results of the proposed research will also be integrated into a new Human-Computer Interaction (HCI) course with an emphasis on potentials of shared haptic user interfaces as an advanced learning technology.

The intellectual merit of this work is a pioneering effort to support students’ collaborative science learning through multiple, realistic and compatible sensorial feedback. The social constructivist learning and participatory design practices, which are the driving design principles in this study, should demonstrate the successful application of theories and evaluation metrics that are inclusive, pluralistic, and generalizable to many other haptic learning system developments. This work will also allow a better understanding of the cognitive and affective impacts of a sensory-based learning-by-collaborating system on science education for students with and without visual impairments. Finally, the multidisciplinary integration of inclusive design, assistive technology, and HCI will facilitate the transfer of basic knowledge to advanced learning technologies to increase STEM accessibility and participation of visually impaired students who should also be trained as a STEM-ready workforce.

The broader impacts of this work lie in several areas. First, the goal is to disseminate the We FEEL SCIENCE system for use nationwide, which will provide very innovative opportunities for young learners with visual impairments as well as special education teachers. Second, the WE FEEL SCIENCE system could also be applied to support collaborative science learning between a sighted student and a visually impaired student. If visually impaired students were in a mainstream science lab, they would have to work with a sighted peer on their hands-on learning exercises. The ability of visually handicapped students to function with other people in groups is increasingly becoming important in society. Finally, this work will have a significant impact on science education by diffusing the knowledge base and practice of STEM curricula involving sensory feedback-based learning-by-collaborating practices.