Annual Report for Period: 09/2010 - 08/2011  
Submitted on: 07/18/2011  
Principal Investigator: Nam, Chang S.  
Organization: U of Arkansas  
Submitted By: Nam, Chang - Principal Investigator  
Award ID: 0953772

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

Project Participants

Senior Personnel

Name: Nam, Chang  
Worked for more than 160 Hours: Yes  
Contribution to Project:
The PI managed the project to achieve its research goals - Design, evaluation, and implementation of 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). More specifically, the PI worked with a graduate student and a visiting scholar to conduct two main research activities proposed for year 1, which are refinement of design requirements and design of a high-level software framework. In addition, the PI worked with advisory board members to review the design requirements obtained in preliminary studies. These activities will be further explained below.

Graduate Student

Name: Li, Yueqing  
Worked for more than 160 Hours: Yes  
Contribution to Project:
1) Helped the PI review and refine a set of design requirements necessary to build shared haptic user interfaces which has previously been identified through a series of preliminary studies and the PI's prior NSF project.  
2) Observed science classes in Arkansas School for the Blind and Kansas State School for the Blind to understand the ways students work together with their classmates and/or their teacher  
3) Helped the PI refine the points of collaboration that need to be supported haptically, audibly, or both, which were identified through two focus group sessions with three pairs of totally blind and partially blind students per session  
4) Helped the PI develop a process where the design requirements obtained in preliminary studies are reviewed again by advisory board members prior to being used in the next step

Undergraduate Student

Technician, Programmer

Other Participant

Name: Woo, Jincheol  
Worked for more than 160 Hours: Yes  
Contribution to Project:
As a visiting scholar with a Master degree in Computer Science, Mr. Woo made the same contributions as Mr. Li did as reported above. In addition, Mr. Woo helped the PI work on software research framework for the development of collaborative haptic interaction techniques. As a Master student was not available in Year 1, this visiting scholar was hired to work on the project. However, a full-time Master student will be hired to work on the project as proposed at a new institution, North Carolina State University.
Research Experience for Undergraduates

Organizational Partners

Arkansas School for the Blind
The PI worked with science teachers in Arkansas School for the Blind and Kansas State School for the Blind, in which they allowed the PI's graduate students an opportunity to observe their classes and understand the ways students work together with other classmates and/or teacher. These graduate students told the PI that through this opportunity they could understand more clearly how a haptically enhanced learning-by-collaborating system should be designed to support blind student's collaborative hands-on practices. Students could also understand how our design requirements necessary to build shared haptic user interfaces should be applied when developing collaborative haptic interaction techniques later, which is the main research goal in year 1 of the project.

Other Collaborators or Contacts
Several advisory board members (e.g., Dr. Smith-Jackson at Virginia Tech, Dr. William McComas at University of Arkansas) helped the PI and his team members review and refine design requirements for collaborative haptic interfaces by providing their expertise in either universal design or science education. As suggested in the proposal, the design requirements will be reviewed once again by so advisory board members prior to being used in the next step. This activity was supposed to be done in Year 1 of the project, but the PI and his research team could not finish it as scheduled due to the PI's transition to a new institution (i.e., North Carolina State University). However, as we are very confident that this activity can be done early in year 2 of the project (e.g., fall of 2011), the PI will be able to report inputs from advisory board members on the design requirements in year 2.

Activities and Findings

Research and Education Activities:
The main research activity proposed in Year 1 of the project was to develop collaborative haptic interaction techniques that allow users, particularly those with visual impairments, to work together in a computer-based learning environment (objective 1a). To achieve this goal, the PI performed several research activities (RA) and education activities (EA) as proposed.

RA 1: The PI collected and refined the set of design requirements necessary to build shared haptic user interfaces which has previously been identified through a series of preliminary studies and the PI's other NSF project.

RA 2: The PI also reviewed the points of collaboration that need to be supported haptically, audibly, or both, which were identified through two focus group sessions with three pairs of totally blind and partially blind students per session.

RA 3: Because the PI proposed that the design requirements obtained in preliminary studies are reviewed once again by advisory board members prior to being used in the next step, the PI's research team has been working on survey design, and it will be conducted early in year 2 of the project.

RA 4: The PI proposed development of nine exemplar haptic techniques that are used with the Novint Falcon? haptic device. The PI and his research team worked to identify possible design changes as well as other collaborative haptic interaction techniques.

EA 1: The PI's team members observed science classes in Arkansas School for the Blind and Kansas State School for the Blind to understand the ways students work together with their classmates and/or their teacher.

Findings:
From RA 1 and RA 3: A set of non-visual design principles and guidelines for the development of haptic user interfaces and haptic hands-on applications have been refined for collaborative haptic interactions. The PI is planning to publish these results in combination with inputs from advisory board members, which was proposed in year 2 of the project.

From RA 2: The PI confirmed several points of collaboration that need to be supported haptically, audibly, or both. Examples include: 1) Spatial Orientation - interpreting one's location in relation to its surroundings, objects, and other users; 2) Shared Awareness - perceiving a condition or event (e.g., location, situation); 3) Co-Navigation - collaboratively moving toward a desired location or goal; 4) Co-Manipulation -
collaboratively changing an object; and 5) Co-Selection - collaboratively initiating an environmental object and/or its key function.

From RA 4: The PI found that adding visual (for those who are partially blinded) and auditory modality can better support collaboration between blind students. The question is, however, how these three modalities (haptic, visual, and auditory) should be implemented when designing collaborative haptic interaction techniques. In year 2, the PI will add these design guidelines to a set of non-visual design principles and guidelines for the development of haptic user interfaces (RA 1 and 3). In addition, we have reviewed different types of software development toolkits, and decided to use Falcon's three API layers for two main reasons: (1) Falcon haptic device is relatively cheaper (about $150) compared to other devices so Blind schools can afford to buy and use; and (2) It is C++ based Software Development Kit (SDK) so it is easy to use for implementation of science learning materials.

From EA 1: By observing science classes in Arkansas School for the Blind and Kansas State School for the Blind, the PI's team members could understand the various ways students work together with their classmates and/or their teacher, which worked well sometime and did not work well other times. In year 2, the PI is planning to publish a summary of lessons team members learned in combination with other research outcomes.

Training and Development:
First, the PI provided his research team members opportunities to learn interpersonal and teamwork skills while working with blind students and science teachers at the blind school.

Second, the PI allowed his team members an opportunity to learn software development kit (SDK) for collaborative haptic interaction techniques (e.g., Falcon's three API layers or Omni's OpenHaptics toolkit), as well as universal and inclusive design principles guidelines through interaction with blind students and teachers.

As proposed in the proposal, these activities should help the PI and his team members conduct the proposed research as planned.

Outreach Activities:

**Journal Publications**

**Books or Other One-time Publications**

**Web/Internet Site**

**Other Specific Products**

**Contributions**

Contributions within Discipline:
Through interactions with blind students and science teachers at Blind School in Arkansas and Kansas, the PI and his research team confirmed our beliefs that providing rich, sensorial feedback can evoke tacit, embodied knowledge necessary for accessible formal and informal learning because many science concepts are rooted in touch. In addition, students can conceptualize and retain a mental model easily if they are immersed in a scientific experience through a learning-by-collaborating environment, which is consistent with learning theories comprising the design philosophy of the WE FEEL SCIENCE system. Collaborative hands-on practices with additional haptic sensory feedback in the WE FEEL SCIENCE system should enhance the level of awareness (e.g., of other's activities), essential to coordinate joint activities, because such awareness can be transmitted through haptic senses other than vision. However, there has been little systematic study of how the shared haptic experiences should be designed and whether they can have the cognitive (e.g., knowledge construction and attitude toward science learning) and affective (e.g., motivation) impacts on students' science learning. At this point, the PI and his research team did not make tangible contributions (e.g., publications), but we do believe that outcomes from this project, which will be made available beginning Year 2 of the project in terms of publications of journal articles and conference proceedings, should provide invaluable insights to research and academic community who wants to support visually impaired students' collaborative science learning through sensorial feedback.
Contributions to Other Disciplines:
The multidisciplinary integration of HCI, universal design, and assistive technology will facilitate the transfer of basic knowledge (e.g., user interface, active learning, etc.) to advanced learning technologies (e.g., shared haptic interfaces for collaborative learning) to increase STEM accessibility and participation of visually impaired students who have been left behind in the technology advances but should also be trained as a STEM-ready workforce. Again the PI and his research team did not make tangible contributions (e.g., publications) yet, but as proposed outcomes from this project will be made available to other disciplines such as universal design, assistive technology, etc., beginning in year 2 of the project in terms of publications of journal articles and conference proceedings.

Contributions to Human Resource Development:

Contributions to Resources for Research and Education:

Contributions Beyond Science and Engineering:

Conference Proceedings

Special Requirements

Special reporting requirements: None
Change in Objectives or Scope: None
Animal, Human Subjects, Biohazards: None

Categories for which nothing is reported:
Activities and Findings: Any Outreach Activities
Any Journal
Any Book
Any Web/Internet Site
Any Product
Contributions: To Any Human Resource Development
Contributions: To Any Resources for Research and Education
Contributions: To Any Beyond Science and Engineering
Any Conference