Preview of Award 1245277 - Final Project Report

Cover

Federal Agency and Organization Element to Which Report is Submitted:	4900
Federal Grant or Other Identifying Number Assigned by Agency:	1245277
Project Title:	TUES 1: Enhancing an Open Laboratory-Based Circuits Experience with a Virtual Laboratory Assistant
PD/PI Name:	Chang-Hee Won, Principal Investigator Joseph Picone, Co-Principal Investigator
Recipient Organization:	Temple University
Project/Grant Period:	09/15/2013 - 08/31/2016
Reporting Period:	09/01/2015 - 08/31/2016
Submitting Official (if other than PD\PI):	Chang-Hee Won Principal Investigator
Submission Date:	10/04/2016
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Chang-Hee Won

---

Accomplishments

* What are the major goals of the project?

Objective #1. Open Laboratory Architecture and Logistics. We will design an open laboratory system architecture. The open laboratory will have multiple modules to enhance student learning. Logistics of running the open lab will be developed.

Objective #2. Virtual Laboratory Assistant with Speech Recognition Interface. Voice is a more natural way for students to communicate, especially when they are confused. Personalization of instruction is also critical when students are frustrated, because they will often interact only when certain social and behavioral defenses are lowered. We will develop a speech based system that can interact with students using a spoken dialog system. This VLA will guide the student's laboratory experience.

Objective #3. Intelligent Pre-laboratory Module. This subsystem will use expert system technology to develop an intelligent tutoring system that will assist the student in responding to the tasks presented by the virtual laboratory. The virtual lab will serve as a pre-lab to the hardware-based laboratory.

Objective #4. Laboratory Instructions for Open Lab. We propose to develop three laboratory modules associate with circuits. The hardware will be available for open-ended laboratory experiment. The main purpose of this module is to deepen the basic circuit concepts through hands on experimentation.

Objective #5. Develop "Khan Academy" Style Topic Explanation Videos. We propose to create a library of "Khan Academy" style circuit topic explanation videos. Naturally, we will verify and link to available resources in the Internet for this part. More electrical engineering circuit related videos will be produced. Instrumentation and safety videos will also be produced.

Objective #6. Assess Student Learning. The smart VLA will keep track of a student's progress. Integrated metrics such as time to completion and the chronological sequence of questions attempted will provide additional insight into student performance. We will also compare results with a control group consisting of students who took the existing course based on more standard lab experiments.

* What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?

Major Activities:
Intellectual Merit: A web-based, virtual laboratory assistant was developed for students participating in a self-paced undergraduate circuits laboratory. The system's components include pre-lab testing and instruction, engineering design exercises, short topic explanation videos, instrumentation instruction (including safety), and a corresponding post-lab test module. In the pre-lab, students were introduced to basic theory and simulation tools to evaluate the theory. If a student needs clarification on a topic, he/she was guided using a short instructional video. These videos utilize a Khan Academy style format and explained many basic (electrical) engineering concepts. The lab instruction module assisted students in executing an open-ended design problem using the VOLTA. The merits of our VOLTA include (1) individual, self-paced learning was possible, (2) 24/7 accessibility, (3) shy or more timid students received personalized instruction in a non-threatening environment, and (4) increased the level of engagement by allowing students to freely explore the subject matter. We found out that the students who learn in an open lab environment performed as well or better than in a traditional closed lab. We verified this with extensive pre- and post-lab assessment.

Specific Objectives:
In this 3rd year, we completed all the objectives. We also performed one more assessment of circuits lab using VOLTA versus traditional circuits lab in the spring of 2016. This time, the TA in VOLTA lab did minimal teaching and encouraged students to use VOLTA.

Significant Results:
Each semester, sophomore-level electrical engineering students were partitioned into two groups: (1) a control group taught in a traditional manner that met once per week at a pre-arranged time with a human teaching assistant, and (2) an experimental group taught once per week at pre-arranged time by a human teaching assistant that also had 24-hour access to VOLTA. We ran the experiment for two semesters in such a manner. Then in the third semester, the human teaching assistant skipped the introductory lecture to the experimental group, but was available for assistance. They were encouraged to use VOLTA from the beginning of the lab.

For the first two semesters, the experimental group taught by VOLTA performed better compared to the control group, where p-value from ANOVA was 0.1714 and less than 0.001. For the third semester, the student learning was similar in the control and experimental groups. A well-designed virtual teaching assistant can support students in an open laboratory environment as effectively as a human teaching assistant.

Key outcomes or Other achievements:
VOLTA is an intelligent system with virtual teaching assistance feature for students in an open laboratory environment. Traditional laboratory environment needs a fixed laboratory space for experiments, whereas VOLTA breaks this constraint. VOLTA provides on-demand help with a self-paced environment and increasing levels of

Filename	Description	Uploaded By	Uploaded On

engagement. Overall, comments from students on this approach were positive. The students found instructional videos, safety videos, and short topic explanations to perform the experiments. In the fall of 2014 and the spring of 2015, the VOLTA taught students performed better compared to their traditionally-taught counterparts in terms of *p*-values of 0.1714 and less than 0.001. In the fall of 2015, the VOLTA-taught students' performance was similar to their traditionally-taught counterparts. These results reveal that VOLTA can provide teaching assistance as good as human teaching assistants for undergraduate electrical engineering students. A flexible laboratory like VOLTA can be a critical part of an effective distance learning strategy and will address the needs of modern, nontraditional students.

* What opportunities for training and professional development has the project provided?

The PI advertised for undergraduate researchers. About ten students applied and the PI chose three of them during the grant period. Total of two graduate students participated in this project.

* How have the results been disseminated to communities of interest?

Yes, we presented posters at two mid-Atlantic ASEE conferences, and two national ASEE conference. We also submitted a journal paper to an educational journal.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
VOLTA_TempleU_NOLA_ASEE_2016_v4.pdf	2016 ASEE National Conference Poster	Chang-Hee Won	10/04/2016

Products

Books

Book Chapters

Inventions

Journals or Juried Conference Papers
Firdous Saleheen, Salvatore Giorgi, Zachery Smith, Joseph Picone, and Chang-Hee Won (2015). Design and Evaluation of a Web-based Virtual Open Laboratory Teaching Assistant for Circuits Laboratory. *122nd ASEE Annual Conference and Exposition, Seattle Washington.* . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Firdous Saleheen, Zicong Wang, Joseph Picone, Brian Butz, Chang-Hee Won (2016). A Web-based Virtual Teaching Assistant for an Open Circuits Laboratory: Design, Implementation, and Outcome Evaluation. *Journal of Computers and Education.* . Status = SUBMITTED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Firdous Saleheen, Ziong Wang, Bill Moser, Vira Oleksyuk, Joseph Picone, and Chang-Hee Won (2016). Effectiveness of Virtual Open Laboratory Teaching Assistant for Open Circuits Laboratory. *123rd ASEE Annual Conference and Exposition, New Orleans, LA.*. . Status = PUBLISHED; Acknowledgment of Federal Support = Yes ; Peer Reviewed = Yes

Licenses

Other Conference Presentations / Papers
Firdous Saleheen, Salvatore Giorgi, Zachary Smith, Vira Oleksyuk, and Chang-Hee Won (2014). *Design of the Virtual Laboratory Assistant for Electrical Circuits Laboratory*. ASEE Mid Atlantic Section Conference. Swarthmore, PA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Chang-Hee Won (2016). *Enhancing an Open Laboratory Teaching Assistant for Open Laboratory*. Envisioning the Future of Undergraduate STEM Education Symposium. Washington DC. Status = ACCEPTED; Acknowledgement of Federal Support

Firdous Saleheen, Salvatore Giorgi, Zachary Smith, Joseph Picone, and Chang-Hee Won (2015). *Virtual Teaching Assistant for Electrical Engineering Science: Initial Study*. Fall 2015 ASEE Mid Atlantic Section Conference. Villanova, PA. Status = PUBLISHED; Acknowledgement of Federal Support = Yes

Other Products

Other Publications

Patents

Technologies or Techniques

Thesis/Dissertations

Websites
Virtual Open Laboratory Teaching Assistant
http://volta.temple.edu/vla/

A web sifte to guide a student in electrical engineering circuits laboratory. The user id is guest and the password is password to test the software.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
VOLTA_ASEE_2016_final3.pdf	2016 ASEE paper.	Chang-Hee Won	09/08/2016
VOLTA_TempleU_NOLA_ASEE_2016_v4.pdf	2016 ASEE Conference poster.	Chang-Hee Won	09/08/2016
Manuscript_volta_cae_submitready.pdf	Journal of Computers & Education	Chang-Hee Won	10/04/2016

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Won, Chang-Hee	PD/PI	3
Picone, Joseph	Co PD/PI	1
Saleheen, FIrdous	Graduate Student (research assistant)	9
Wang, Zicong	Graduate Student (research assistant)	9
Goldstein, Jesse	Undergraduate Student	1

Full details of individuals who have worked on the project:

Chang-Hee Won
Email: cwon@temple.edu

Most Senior Project Role: PD/PI
Nearest Person Month Worked: 3

Contribution to the Project: Principal investigator. Managed the project which includes scheduling, assigning tasks, verifying the tasks, and reporting the results.

Funding Support: NSF, Temple University

International Collaboration: No
International Travel: No

Joseph Picone
Email: joseph.picone@gmail.com
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Co-principal investigator. Managed the project especially the speech interpretation part.

Funding Support: NSF, Temple University

International Collaboration: No
International Travel: No

FIrdous Saleheen
Email: tud07296@temple.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 9

Contribution to the Project: Implement and test the Virtual Open Laboratory Teaching Assistant.

Funding Support: Temple University, NSF

International Collaboration: No
International Travel: No

Zicong Wang
Email: tuf73139@temple.edu
Most Senior Project Role: Graduate Student (research assistant)
Nearest Person Month Worked: 9

Contribution to the Project: Tested VOLTA and developed circuit comparator

Funding Support: Temple University, NSF

International Collaboration: No
International Travel: No

Jesse Goldstein
Email: tuf03060@temple.edu
Most Senior Project Role: Undergraduate Student
Nearest Person Month Worked: 1

Contribution to the Project: Making videos and testing of VOLTA

Funding Support: NSF, Temple University.

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?
Nothing to report.

What other collaborators or contacts have been involved?
Nothing to report

Impacts

What is the impact on the development of the principal discipline(s) of the project?

This project will impact undergraduate engineering laboratories. Open lab concept will be implemented in this project via a web-based software to act as a teaching assistant. Students will perform electrical engineering circuits lab on-demand. The VOLTA software will act as an teaching assistant and guide the students to perform the lab.

What is the impact on other disciplines?

The developed architecture for VOLTA can be used in other courses such as control systems, communications as well as other disciplines such as biology, physics, chemistry, and computer science. VOLTA architecture allows a labs to be open lab.

What is the impact on the development of human resources?

We trained one undergraduate student and two graduate students about software engineering and Python programming.

What is the impact on physical resources that form infrastructure?

The virtual open laboratory teaching assistant (VOLTA) software for circuits lab is developed in this project. This was used in introductory engineering circuit labs.

What is the impact on institutional resources that form infrastructure?

Utilizing VOLTA, TAs will perform a different function. Mostly, they will answer difficult questions instead of routine questions such as how to use the equipment. The students will be able to do the lab at their convenience, which will enhance learning.

What is the impact on information resources that form infrastructure?

The effectiveness of student learning using VOLTA in the circuits laboratory and traditional lab are assessed. Students who used only VOLTA without the teaching assistant learned as much as the students in the traditional lab. If VOLTA is used along with a human teaching assistant, students learned more than just having the traditional lab with a human teaching assistant.

What is the impact on technology transfer?

There is a potential that this product can be commercialized along with hardware company such as Digilent and National Instruments.

What is the impact on society beyond science and technology?
Nothing to report.

Changes/Problems

Changes in approach and reason for change
Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them
Nothing to report.

Changes that have a significant impact on expenditures
Nothing to report.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.

Special Requirements

Responses to any special reporting requirements specified in the award terms and conditions, as well as any award specific reporting requirements.
Nothing to report.