Learning by Immersion: Developing Virtual reality Labs for Engineering Courses

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A solid understanding of electromagnetic theory is key to the education of electrical engineering students. However, concepts in electricity and magnetism (E&M) are notoriously challenging for students to learn, due to the difficulty in grasping abstract concepts such as the electric force as an invisible force that is acting at a distance, or how electromagnetic radiation is permeating and propagating in physical space. Building physical intuition to manipulate these abstractions requires means to visualize electromagnetism concepts in a three-dimensional space. This project involves the development of 3D visualizations of abstract E&M concepts in Virtual Reality (VR), in an immersive, exploratory, and engaging environment, with the potential to be adopted by Engineering, Science, Mathematics and Medical college curricula across the country.

VR provides a disruptive platform for teaching and learning, in a realistic and most importantly, interactive three-dimensional environment. There are many advantages for using VR as a teaching tool, as it has the potential of addressing many challenges traditional teaching usually faces, and can lead to increased student engagement while removing some of the anxiety student experience while in active learning environments. Virtual Reality provides the means of exploration, to construct visuals and manipulable objects to represent knowledge, which in turns leads to a constructivist way of learning, in the sense that students are allowed to build their own knowledge from meaningful experiences.

The VR labs for E&M courses in the ECE department are generated by Electrical Engineering and Computer Science students enrolled in the “Virtual Reality” course at the same university, as part of the course term projects. This reflects the strong educational impact of this project, as it allows students to contribute to the educational experiences of their peers. Student competencies around conceptual understanding of electromagnetism topics, as well as their understanding of mathematical concepts, are measured via formative and summative assessments. To evaluate the effectiveness of VR learning, each VR experience is followed by a short 10-minute multiple choice
test, designed to primarily measure conceptual understanding of the various topics, rather than measuring the ability to simply manipulate equations, and will be tied to the specific contexts and topics of that lab's instruction.

This paper discusses the implementation and the pedagogy of the Virtual Reality laboratory experiences to visualize concepts in E&M, with examples for specific labs, as well as challenges, and student feedback with the new approach. We will also discuss the integration of the 3D visualizations into lab exercises and the design of the student assessment tools used to assess the knowledge gain when the VR technology is employed. In addition, we discuss the development of VR labs to visualize concepts pertaining to elements vector calculus, designed to enhance student understanding of the nature of operators such the gradient, curl and divergence, as well as the development of VR labs to visualize concepts pertaining to spatial geometry and coordinate transformations.