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Board 377: Research Experiences for Teachers in Simulation and Visualization for Innovative Industrial Solutions: Year 2

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Research Experiences for Teachers in Simulation and Visualization for Innovative Industrial Solutions: Year 2

Abstract

This paper discusses results of the second cohort of teacher participants in the Research Experiences for Teachers (RET) Site at Purdue University Northwest, a computer intensive simulation and visualization research site for high school teachers and community college instructors. The six-week research experiences took place in the Center for Innovation through Visualization and Simulation and involved working on research projects from the steel industry related to computational fluid dynamics (CFD), Finite Element Analysis (FEA), and interactive 3D and virtual reality software development for safety training. Both summers had cohorts of 11 teachers. The second cohort invited back 6 of the first-year teachers to continue their research and serve as mentors for 5 new teachers.

The second-year research experience followed a similar structure to the first year, but was modified based on evaluation and feedback to improve research outcomes. The cohort generally met for full group seminars and discussion once per day, followed by individual time with their research mentors. Some of the returning teachers chose to continue their research from the previous year, but most of the group began new research projects. The summer began with literature review and defining research problems. There were four main research projects, led by four research mentors. Groups of teachers were paired with the research mentors and graduate students who were working on complimentary research problems. Each teacher defined a research problem unique to them, for a total of 11 individual research projects within the four main research areas of Blast Furnace Fuel Simulation, Reheat Furnace Simulation, Finite Element Analysis of Structures, and Safety Training. Teachers completed the research and presented results at the end of the 6-week summer session. Each teacher also developed and presented a lesson plan related to their research which was to be implemented in their classroom during the 2022-23 school year.

Evaluation included pre & post measurement of teacher's self-reported ability to complete research tasks such as defining a research problem, conducting literature review, and evaluating and communicating results of research. Follow-up activities are ongoing during the teacher's academic school year, including carrying out the lesson plans in their classroom, teachers traveling to conferences related to their field, and introducing students to careers in simulation, visualization, and industrial research, as well as STEM in general through presentations and field trips.

Introduction

STEM Education provides students with multidimensional capabilities that are necessary to meet current and future workforce needs due to constant technological advances in nearly all industries

[1-4]. Unfortunately, only a small portion of students are both proficient and interested in STEM fields [5]. Researchers suggest that STEM teachers are often underprepared for these demands, since they do not have content knowledge or expertise in teaching STEM topics [6]. Evidence suggests that teaching engineering concepts using real-world examples significantly increases student success rates [7-9]. This project addresses these issues by involving teachers in authentic industrial research projects, helping them build advanced skills in the specific area of simulation and visualization research, and helping them to develop lesson plans and content to relate the research experience back to their students during the academic school year [10].

The Center for Innovation through Visualization and Simulation (CIVS) at Purdue University Northwest was established in 2009 and is globally recognized for its integrated and application-driven approaches to solving real-world problems with cutting-edge simulation and visualization technologies. CIVS works closely with industry, K-12 schools, colleges, and governmental branches to address critical issues in engineering, energy, productivity, quality, safety, education, and the environment. CIVS uses computational models to simulate real phenomena and predict their behavior under specified conditions, and visualization technology to create 3D images and virtual reality environments. Integrating simulation and visualization enables effective data analysis and presentation, communication of ideas, and problem solving, and promotes effective creation of virtual teaching/learning modules with real-world scenarios.

Through partnerships with over 110 external organizations, CIVS has completed over 230 virtual design and virtual education projects with steel-associated and other industries, saving collaborators over $40 million. A number of virtual teaching/learning modules have been implemented and evaluated for technical and engineering education, as well as for training in industry [11-19].

This project's RET in Engineering site is located at Purdue University Northwest, a regional Purdue campus in Northwest Indiana (NWI), and focuses on active research projects being carried out in collaboration with the steel industry and other related manufacturers. The first two years of the project each enrolled 11 high school and community college teachers from schools within the region, specifically economically depressed areas, and historically associated with "non-glamor," heavy industries such as steel and manufacturing. The second cohort completed their 6-week research experience during the summer of 2022 and is currently implementing their follow-up academic activities in the classroom during the academic year.

Goals and Objectives

With the overall goal of providing high school and community college STEM teachers with research experiences and development opportunities that will enhance their STEM understanding and in turn be adapted into class curricula, the project identifies these **three objectives**:

(1) To provide high school and community college teachers with authentic research experiences using advanced simulation and visualization technologies to solve real-world industrial problems. Through the research experiences, teachers will learn to use simulation and visualization for applied research in various engineering fields, which will be transferred back to their classrooms

(2) To translate teachers' research experiences and knowledge into curricular modules, utilizing existing real-world virtual industrial processes, that will be implemented in their STEM classes during the academic year

(3) To build a community of educators and engineers who will continue to collaborate, promote research and practical application of simulation and visualization technologies, advance STEM learning and career paths, and provide inspiration for students [10].

Methodology

Technical Approach

The research projects carried out by the teacher participants followed a methodology developed by CIVS for combines numeric simulation, sensor data, and scientific visualization with 3D and immersive visualization for multiple platforms (Figure 1) [20]. Teachers worked with research mentors to perform a literature review and define a specific research problem within one of four ongoing research projects using simulation and visualization with manufacturers in the region.

Teachers developed a research plan and spent 6 weeks during the summer learning the necessary skills to carry out the research. Graduate students who had already been working on the research projects also interacted and assisted the teachers throughout the summer. The research was performed largely in computer labs, but also involved field trips to steel mills and discussions and collaboration with industry personnel. Teachers wrote a short technical paper to summarize their research results, developed lesson plans to relate the research to their students during the following academic year, and presented their research results and lesson plans at the end of the 6-week period.

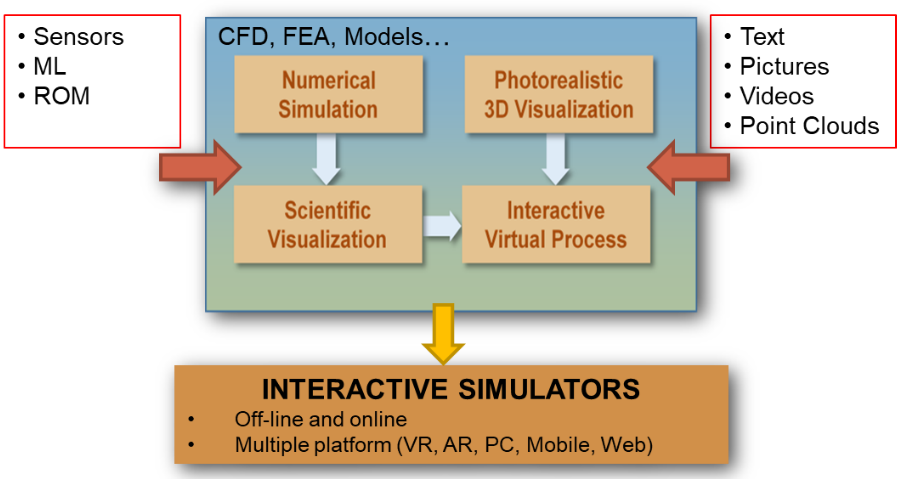

Figure 1. Technical approach for the research projects

Research Projects

Four large-scale research projects were provided as options for the teachers. Each project had a dedicated research mentor and each teacher worked with their mentor to identify and define a specific research problem within one of the projects. In this manner, the cohort was broken into four sub-groups (one for each large-scale project). Summer activities included a mix of full-group activities (seminars, field trips), sub-group activities (small group meetings with their research mentor), and individual activities (carrying out the research activities, collecting data, developing software and/or simulations). The four large-scale research projects were:

- Investigating the Effects of Natural Gas (NG) Injection in a Blast Furnace [21, 22]
- Investigating the Effects of Operating Conditions on the Energy Efficiency of a Slab Reheat Furnace [23, 24]
- Investigating the Effects of Operating Conditions on the Stress and Lifespan of an Overhead Crane [25]
- Investigating Techniques for Interactive Safety Training in the Steel Industry [26-29]

Results

The summer session for this second cohort provided eleven teachers with the opportunity to explore research projects, as well as learn simulation software, in accordance with the classes that they taught and their interests. Projects were supervised by a research faculty or staff member and a graduate student researcher, and the scope of the projects was adjusted to the teachers' skills and capabilities. All teachers were given dedicated space to carry out their research activities and support to ensure success within the summer timeline.

Figure 2. Teachers toured a steel mill and discussed their research with personnel on site. The visit included loud and hot production settings as shown above, as well as quiet and cool lab settings with various testing equipment.

During the course of the summer, teachers visited a steel mill (Figure 2) to see the processes environment where their research would be applied. The teachers were also able to discuss their research with various personnel and ask questions on-site. While some processes, such as injection of natural gas into the blast furnace couldn't be observed directly, the teachers gained an understanding of the scope and scale of the processes, and learned how research fit within the real world setting. This was point was emphasized by multiple teachers during a group discussion to reflect on the visit. Before the visit, the group was largely unaware of the high-tech STEM careers that existed "behind the scenes" of the heavy manufacturing setting, and mentioned looking forward to sharing the experience with their students.

Figure 3. Teachers concluded the summer by presenting their research outcomes, lesson plans, and discussing plans for implementing their research experiences into their classrooms during the academic school year.

Teachers concluded the 6-week summer research experience with a final presentation of their research results, reviewing the lesson plans they had developed, and discussing follow-up plans for the academic year (Figure 3).

Future Work

At time of writing, the second cohort of teachers are currently in their academic school year and the project team is meeting with them individually to assist and ensure the plans from the summer are being implemented in the classrooms. In addition to their lesson plans, several teachers also plan field trips related to their research and some of also identified and attended teaching conferences in their respective fields to network and share their experiences with other teachers. Recruitment has also begun for the third cohort of teachers which will run during Summer 2023.

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