Research and Development of Immersive Computational Thinking Tools using Virtual Reality, Natural Hazards Data, and Scientific Visualization to Engage K-12 Students in Scientific Computing and Engineering Education

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Abstract

The NHERI DesignSafe-CI Research Experience for Teachers (RET) supplement recruits two high school teachers to work alongside faculty, researchers, and staff of the Texas Advanced Computing Center (TACC) at The University of Texas at Austin. Teachers participate in graduate-level research within the fields of computing and engineering with a particular emphasis on the intersection of natural hazards data, virtual reality, and scientific visualization.

The research focus in 2019 was the use of NHERI data, A-Frame and WebVR framework, and TACC visualization resources to create natural hazards design features in a virtual reality environment. Professional development and training from TACC supported research deliverables, including a lesson plan aligned with Texas Essential Knowledge and Skills (TEKS) state standards, and a live demo to support TACC's education and outreach activities for K-12 and the general public.

This poster will present the research process, highlighting TACC resources used, challenges and successes, and dissemination efforts.

Introduction

Broadening engagement in scientific computing and engineering education drives the development of instructional content that leads to implementation into the classroom and outreach curriculum.

Project Goals:

- Development and instruction of lessons that interconnect the current research fields of natural hazards engineering with computer science and engineering.
- Use of simulations and animations created for NHERI researchers, such as wind-induced pressure distributions on building models tested at the Multi Hazard Research Lab wind tunnel at the University of Florida and supported by TACC resources.
- Creation of VR experiences for the Oculus Rift VR headset to provide direct engagement between high-level research and K-12 students in formal and informal educational settings.

Outcome: promote opportunities in computer science, computer engineering, and natural hazards engineering as exciting careers that leverage NHERI Facilities to create interactive experiences for K-12 and public consumption.

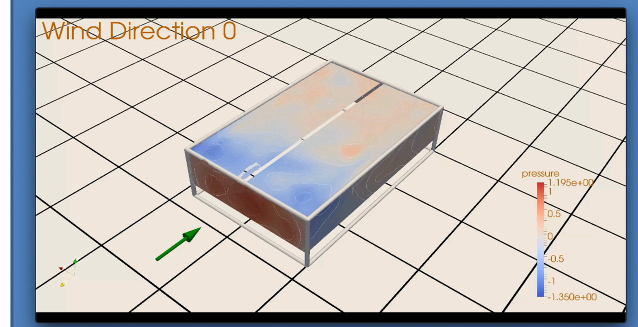

Figure 1. Wind Direction 0 degrees

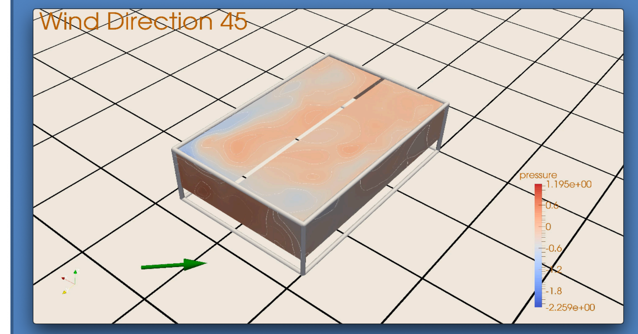

Figure 2. Wind Direction 45 degrees

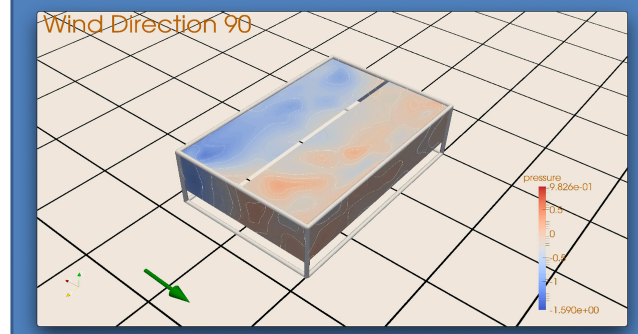

Figure 3. Wind Direction 90 degrees.

Wind-induced pressure distribution (over time) on a building model

- *illustrated by color mapping and contour line distribution on the surface of the model*
- *The model was tested at the Multi Hazard Research Lab wind tunnel at the University of Florida.*
- *Three (3) different wind directions were tested. Pressure data was collected at 625 Hz.*
- *The raw data was subsampled and interpolated across the surface of the computer-modeled wind tunnel.*
- *Blue regions on the roof of the model represent low pressures and a lifting force on that area. Upwind corners of the building experience a lifting force that can result in roof failure.*

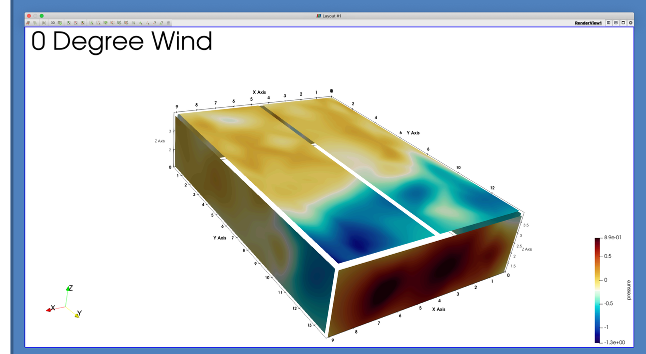

Figure 4. Wind Direction 0 degrees

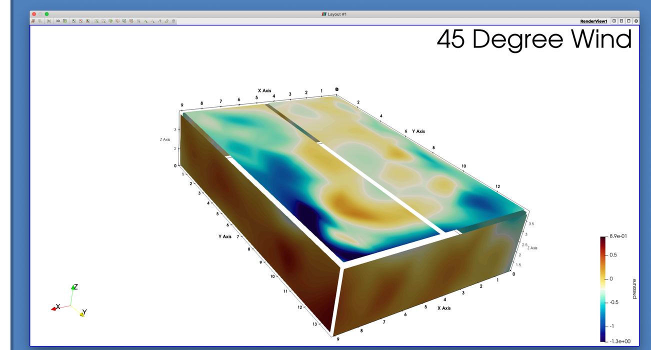

Figure 5. Wind Direction 45 degrees

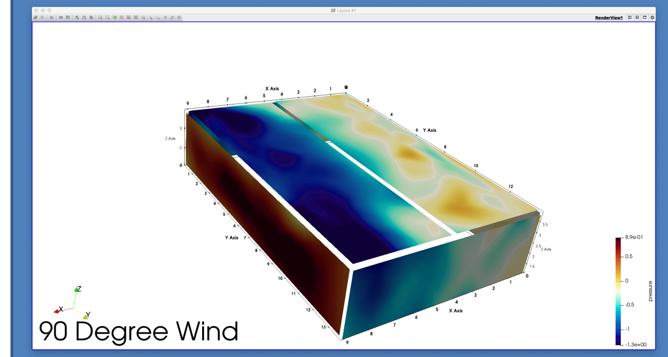

Figure 6. Wind Direction 90 degrees.

Wind-induced pressure distribution (over time) on a building model using ParaView

- *A different color mapping and contour line distribution on the surface of the model was implemented*
- *The original VTK data files were used to create simulations within ParaView*
- *The same three (3) different wind directions are represented in the ParaView model*
- *Educators would require a compatible computer, ParaView software, and HTC Vive to conduct the lesson plan.*

Methods and Research

1. Professional development and Training.
   a. Scientific Visualization workshop led by TACC researchers.
   a. WeTeach_CS Summit 2019.
   b. Visit, ParaView, WebVR, and A-Frame.
2. Collaboration with TACC visualization experts to create rich and informative hands-on scientific visualizations.
3. Application of new research into daily findings.
4. Feedback implementation.
5. Use of wind data (Figures 1-3) from NHERI and TACC Human Data Interaction Lab to use ParaView.
6. Update original project scope to allow the use of the HTC Vive VR headset.

Challenges

1. Software/hardware incompatibility - recreating the 3D representation within Unity and A-Frame were unsuccessful. Representing scientific visualization using A-Frame and WebVR is still a new approach that requires further study.
2. Getting the data to run through a simulation using VR and the Oculus Rift.
3. Color preservation.

Results

1. Creation of an interactive 3D representation of the NHERI wind data using ParaView (Figures 4-6).
2. Use of A-Frame, a web framework for building virtual reality experiences, to place individual time-frames of data with its colors preserved.
3. Transferring the data into Unity, a real-time 3D development platform.
4. Curriculum aligned with TEKS to engage K-12 students in scientific computing and engineering education.

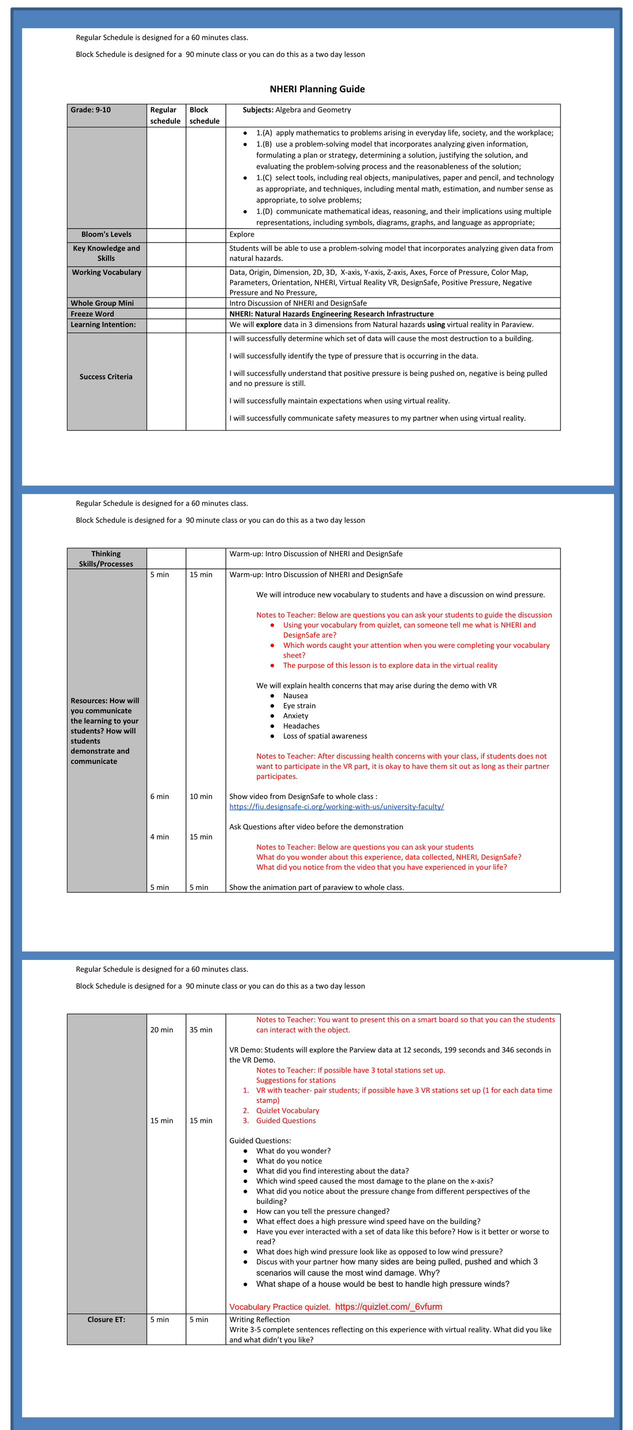

Figure 7. NHERI DesignSafe-CI Lesson Plan

Discussion

Introducing new technology into the classroom can be challenging for educators and students alike. The following questions arose during the teachers' research:

1. How can the research be presented in a relatable way to students?
2. How can the lesson plan and materials be scalable to broaden impacts for other communities?
3. How is lesson comprehension measured and how would it affect further research?

Conclusions

Teachers plan to implement the lesson plan (Figure 7) during the 2019-2020 academic year. Using ParaView and the HTC Vive VR headset, students will be able to view different angles and wind pressure of the VR building model. Students will also be able to interact with the data while walking around the VR building model. Additionally, the VR model will be showcased at the TACC Visualization Laboratory to engage K-12 and the general public.

Future Directions

Research will be presented at professional conferences and workshops, and teachers will provide professional development to other educators. The project formally ends in February 2020, until which time the teachers will continue to work on successfully transferring the wind data into A-Frame. While using ParaView was successful, it still requires a dedicated computer and VR headset powerful enough to run. For most educators, this may not be the most accessible option. A-Frame is considered a viable option that is user-friendly and accessible to most educators.

Contact Information

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https://www.designsafe-ci.org/#learning

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