ENGAGING STEM STUDENTS USING AFFORDABLE VIRTUAL REALITY FRAMEWORKS

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Challenges faced by STEM institutions in implementing ‘interactive’ strategies to promote active learning & problem-based learning (AL/PBL)

Constraints/limitations pertaining to
- Equipment
- Space
- Infrastructure
- Budget
- Safety

Graphics-based interaction with materials engages students and promotes problem-solving skills
SESSION
OBJECTIVES & OUTLINE

• Objectives of the Session
  1. Provide detailed insights into the effectiveness of affordable graphics-based frameworks in STEM education
  2. Ability to take a 'discipline-specific' STEM instructional problem & present materials in stimulating manner

• Design and implementation of frameworks using different modes of Virtual Reality (VR)

• Break-down a discipline-specific 'challenge' area in STEM instruction for developing low-cost graphics based VR introduced
VR & VR MODES

- Why VR?
- What are the actual targeted benefits?
  - Navigation?
  - Interaction?
  - Immersion?
- What modes are available?
WHAT IS VIRTUAL REALITY (VR)?

“Basically, VR is about using computers to create images of 3D scenes with which one can navigate and interact.” – Vince, J. (2004)

VR MODES

• Use of graphics modules in 3 VR modes:
  • Immersive VR
  • Augmented VR
  • Desktop VR
IMMERSIVE VR: CAVE

- CAVE – Computer Assisted VE
  - Offer high end fidelity, immersion and navigation
  - Large spaces and cumbersome installation procedures
  - Significant costs: Installation, operation and maintenance
  - Financial constraints associated with equipment/space infrastructure significantly constrain STEM institutions from implementing ‘interactive’ strategies to promote active learning and problem-based learning (AL/PBL)
AUGMENTED VR (aVR)

- HMDs (capabilities based on specifications)
  - Resolution
  - FOV (both for horizontal/vertical)
  - Cost

- With some HMDs, wider field of view can be achieved, however may sacrifice resolution fidelity
Visualization / Simulation displayed on screen

By themselves, dVR
  • Easy to use
  • Portable
  • Affordable

But, not good immersion & fidelity

Hence, Mixed VR or aVR can be a good compromise
• Visual presentation of the information
  • Stimulates Interest
  • Facilitates Understanding
  • Reduces Cognitive Load

• Active learning methods
  • Graphics based interaction with materials engages students and promotes problem-solving skills.
  • Problem-solving and project-based learning
  • Facilitate better understanding of subject material and applying classroom learning in workplace
Affordable VR frameworks delivered using multiple VR modes

1. Cleanroom Simulation
2. Programming Instruction & Computational Thinking
3. Manufacturing Instruction- Virtual ROV Assembly
4. Computer Hardware Instruction

Finally, a clear demo of the vital elements involved in designing and implementing an interactive STEM application
IMMERSIVE VR: CLEANROOM SIMULATION

CAVE - Immersive VE where projectors are directed to 3 / 4 / 5 / 6 of the walls of a room-sized cube

Demo of a sample application in Immersive VR (CAVE)

CLEANROOM SIMULATION

• Each student performs the following tasks:
  • Identify contaminants violating safety regulations
  • Familiarize with medication labeling standards
  • Apply alcohol swab to vials and bag seals
  • Aseptically inject medication into IV-Bag
  • Dispose syringe needle tip
VR SAFETY GAME

Introduction to Safety Game

Objective: The purpose of this interactive 3D game is to allow the student to practise hazard identification skills associated with grinder operation in a virtual mechanical laboratory.

Success: If you have resolved all safety hazards related with grinder operation, you can turn on grinder machine. A success message will pop up. This will indicate that you have successfully identified all safety hazards, and picked up all necessary equipments for protecting yourself.

Failure: If you did not resolve all safety hazards or did not pick up necessary protection equipment related with grinder operation, you could not pass this game. A failure message will pop up.

Click "Enter" key to move to next page

Acknowledgements:
Profs. Ge Jin & Shoji Nakayama (Purdue NW) for sharing this from earlier research efforts.
CAVE: PROS AND CONS

- Advantages: High fidelity, immersion, navigation

- Disadvantages of CAVE:
  - Require large spaces
  - Costly Installation, Operation, & Maintenance
  - Not portable
  - Are not quite helpful for dissemination/access
VR IN STEM DISCIPLINES

STEM APPLICATIONS USING VIRTUAL REALITY
HARDWARE INSTRUCTION
INTERACTIVE GRAPHICS FRAMEWORK TO INSTRUCT STUDENTS ON COMPUTER HARDWARE
• ROVs are one of the best practical and safest ways to perform underwater exploration.

• Exploring the sea and underwater areas for treasures and for salvaging sunken cargo, seafood etc.
• Scene – made of elements with properties or attributes
• Parent/Child Relationship
• Hierarchical arrangement helps in the step-by-step design of the object and also understanding the framework at any later stage.
• A scene-tree construction is used in Virtual Scene Renderings. Using ‘parent-child’ relationships.
Even though the user can navigate within the VR world and explore the ROV themselves, the OLE interface ensures that beginners or trainees go through the steps in the proper sequence to understand the ROV Assembly process.
LOW-COST VR FOR ALTERNATIVE SCENARIO VISUALIZATION
Partial View of the 3D Rendering of the ROV Model
DESIGN & IMPLEMENTATION
HOW IS IMPORTANT, BUT SO ARE ‘WHAT’ & ‘WHY’

- How (the software and hardware aspects are important)
- What and Why are also equally important
<table>
<thead>
<tr>
<th></th>
<th>4-Sided CAVE (Details based on a standard CAVE)</th>
<th>Full-Fledged CAVE - 6 sided, HR Multi-Projection Screens, Cluster(s)</th>
<th>Consumer VR HMD system</th>
<th>Desktop VR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Display</strong></td>
<td>Barco NW7 projector at 1356x1080 per display @ 120hz Each projection - 8' by 10' (300k)</td>
<td>- RearProjected Optically Blended MP system (&gt; 2 mill min)- Resolution (1920 x 1920 120Hz Active Stereo)</td>
<td>Oculus Rift: 1200x800 (600x800 per eye) at 60Hz. Stereo side-by-side</td>
<td>Standard LCD Monitor</td>
</tr>
<tr>
<td><strong>FOV (Hori)</strong></td>
<td>270 degrees (max.)</td>
<td>360 degrees</td>
<td>&lt; 110 degrees</td>
<td>20” from screen, approx.. 60 deg</td>
</tr>
<tr>
<td><strong>Machine</strong></td>
<td>HP Z800 workstation +Quadroplex d2</td>
<td>Cluster-driven 6 – 12</td>
<td>(A Standard gaming pc/laptop</td>
<td>Standard Gaming PC/WS</td>
</tr>
<tr>
<td><strong>Tracking</strong></td>
<td>YES Intersense – 100k</td>
<td>Yes. Wide Range Possible (OT – 25k /Intersense-100k)</td>
<td>YES Display &amp; rotational tracking</td>
<td>NO</td>
</tr>
<tr>
<td><strong>Immersion</strong></td>
<td>High</td>
<td>Very High</td>
<td>Medium High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Equipment + Installation</strong></td>
<td>1.5 M Approx</td>
<td>2 M Approx</td>
<td>$ 2500</td>
<td>$ 2,000</td>
</tr>
<tr>
<td><strong>Op/Maintenance Cost</strong></td>
<td>30 k Maint/year 50 k Operation</td>
<td>50 k /annum (Maint.) 100 k /annum Op</td>
<td>Negligible</td>
<td>Negligible</td>
</tr>
</tbody>
</table>

SOFTWARE

- Virtual scenarios - x3D/VRML and Unity platform
- Unity3D - game engine capable of rendering through either through OpenGL or DirectX
-
HARDWARE

- **Desktop/Laptop**
  - HP Z800 machine – HP graphics workstation
  - Alienware Series or Oculus compatible laptops

- **Samsung C7000 46 inch 3D TV**
  - 120 Hz system that uses its own proprietary glasses for binocular vision

- **Razer Hydra**
  - Built specifically for game industry. Recent surge in use of the Hydra for DIY-VR

- **Microsoft Kinect**
  - Gaming interface MS Xbox; but, this research uses Kinect as the tracking interface (head-tracking of the users)
STEM APPLICATIONS

All Applications are not equal

Simple Games for Logic Instruction
Different STEM disciplines have varying course work and lab requirements.

The Remotely Operated Vehicle & Hardware Instruction are different from Programming Instruction.
CRITERIA TO CONSIDER

- What is the level of User Interaction required?
- What level of immersion is required? (Is Immersion required?)
- What is the level of interaction required?
- What level of Graphic Design is required (target audience?)
- What are the limitations
  - Cost
  - Time
  - Space
CRITERIA TO CONSIDER

- User Interaction
- Event Driven Interface
- EAI (External Authoring Interface) Programming (or) Scripting
- Different types of mouse actions that can be used include mouse Cursor Click, cursor movement (hover), and mouse click / drag.
CONCEPT - DRIVEN GRAPHIC DESIGN

- A picture is worth a thousand words --- TRUE
- Desktop or Augmented – substantial visual element
- Good planning and storyboarding
STEP-BY-STEP

PLEASE REFER TO THE HANDOUT-2

• Programming Instruction (Chosen for simplicity & to prove that simplicity works too)
• Concept Inventory
• Breakdown: Divide into Modules
• Storyboard – Layout
• Plan interaction for fun and reduction in cognitive load
• Programming Example
THANK YOU!!!

QUESTIONS?