Educational Augmented Reality Tools: Development, Implementation, and Assessment of Phase I

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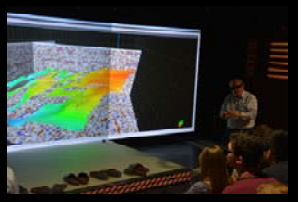
TAMUQ Research Computing virtual reality activities ...

- ENGR 111 students are introduced to various engineering programs with the help of several VR experiences.
- Students from Petroleum engineering present their senior design projects every year to faculty and industry in the VR lab (CAVE).
- High school students are given the facility demo for the development and outreach purpose throughout the year.
- Developing virtual field trips in VR to oil and gas facilities to enhance the student learning experience



Dr. Mike Bowman teaching about the oil/gas reservoir

Dr. Aziz Rahman presenting his research on slug flow in the pipeli

A 3D model of an oil production platform

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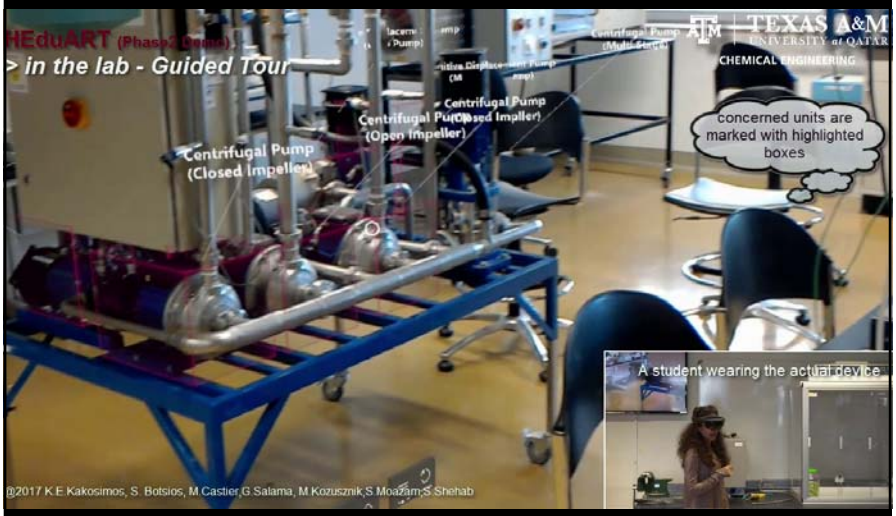
TAMUQ - HEduART **...but you have not seen these!!!**



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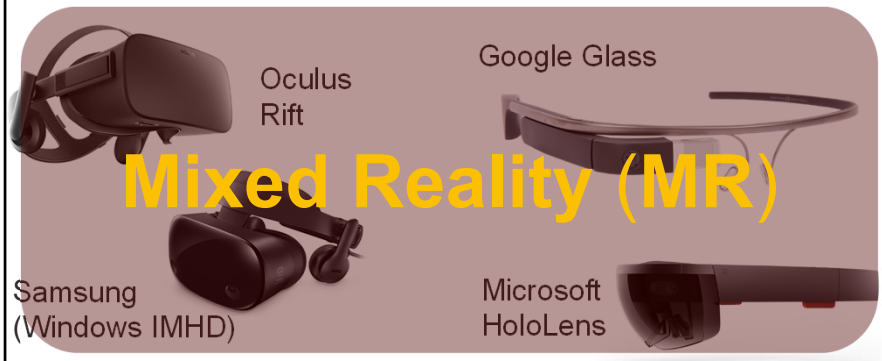
...today

Virtual Reality (VR) is a computer-generated **immersive environment** that can be similar to the real world or fantastical or creating an experience not possible in our physical reality [WikiPedia]

Augmented reality (**AR**) is a live direct or indirect **view of a physical, real-world environment** whose elements are "augmented" by computer-generated or extracted real-world sensory data [WikiPedia]



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my wish list

AR technology…in the classroom, warehouse and lab for …

- Teaching & Training ← **As a Tool**
  - Recording material like Training
  - Prepare instructions & Capture operating procedures
- Operation ← **For Developing Tools**
  - Watch material
  - Follow instructions
  - Automatic retrieval of information (scanning objects)
  - Communication (video conferencing)
- Beyond ← **As an Enabler**
  - Evaluation of performances
  - Safety
  - Medical applications

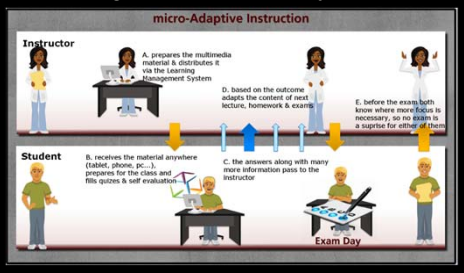
methodology

AR technology…in the classroom, warehouse and lab

- Assess
  - existing technology and
  - visual support tools
- Develop demonstration platforms for
  - Training and
  - Operation
- Three case studies
  - Case 0: Augment Home Reading with Multimedia (non-AR; 2013)
  - Case I: Augment a Laboratory Environment Google Glass (2014)
  - Case II: Augment a Training Environment MS Hololens (2016)
  - ….
- **Lessons Learned**

CASE 0: **Micro-Adaptive Instruction**

- Aiming to increase quality "contact" time with students



- Students were happy to spent 4x more time
- 71% positive feedback
- ~ 1 letter grade improvement (compared to reference study)

- Awards
  - 2013 Winning Project, 1st Teaching Innovation with Technology Competition, TAMUQ
  - 2014 Best paper, Engineering Leaders Conference, Doha, Qatar
  - 2015 Hutchison Medal, Institution of Chemical Engineers, UK

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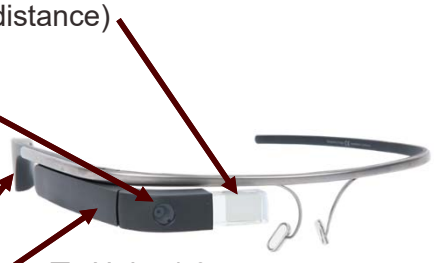
CASE I: **Google Glass**

- Android v4.4
- Display HD (i.e. 25" at 3 m distance)
- CPU 1.2Ghz Dual(ARMv7)
- Photos 5 Mp Videos 720p
- Wifi 2.4 GHz, Bluetooth
- 1 GB Ram
- Battery 670 mAh (~ day)
- Bone conduction audio
- Gyroscope, accelerometer & magnetometer
- Side track pad



- Unity 4.0
- Vuforia Framework (for AR and QR codes)
- Android SDK framework

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CASE I: **Visual support on lab work**

- Outline
  - 7 students (started with 18) w & w/o the Glass
  - Collect time performance and COMMENTS
- Exact same instructions (on paper and Glass)
  - No sound, video, interaction
- No previous training (1st in the lab and process)
- "Pretend" execution of steps with hazard
- Thermo-gravimetric Analysis (TGA)
  - Check gas regulators
  - Turn on equipment and check values
  - Start software and set configuration
  - Prepare and add sample

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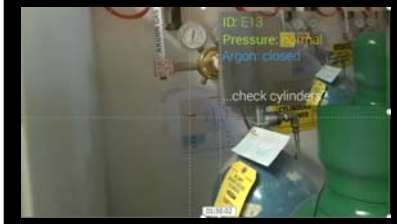
CASE I: **Visual support on lab work**

Transfer process details from the PC to Glass

Recognize wrong (correct) use of tools/samples



Recognize position and feed appropriate information

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CASE I: **… identifying Safety & Hazards**

Use labels as proxies for safety information

Identify physical objects (fire extinguisher) and prompt safety updates

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CASE I: **… teaching Safety & Hazards in the lab**

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CASE I: Training Demonstration with Students - Outcome

Pre-trials and post-trials survey results for assessing the learning and training factor.

- ❑ Q1. I prefer recorded material over written instructions for this type of training
  Pre-training 100% Post-training 100%
- ❑ Q2. Video instructions are useful and easy to follow
  Pre-training 100% Post-training 85%
- ❑ Q3. Paper instructions are useful and easy to follow
  Pre-training 30% Post-training 60%

CASE I: Training Demonstration with Students - Outcome

- o Optics need improvement
  - o Display not always clear
  - o Bigger?
- o Trackpad too sensitive in some occasions
- o Easily distracted by the displayed information
- o Auto dimming too short

- ✓ Sound and Animation should be included
- ✓ Automatic Navigation
- ✓ Free hands

- ➢ **Neither the technology no platform is there yet…**

CASE II: **Microsoft HoloLens**

- Windows 10
- 2x HD see through holographic lenses
- 2.3 million points holographic resolution
- HPU 1.0 Intel 32-bit
- Photos 2 Mp Videos HD
- Wifi 2.4 GHz, Bluetooth
- 2 GB Ram
- Battery (2-3 hours active)
- External speakers
- Environment cameras, light sensors, microphones

- Unity 5.0
- Windows ToolKit
- Visual Studio

- Solidworks
- Blender

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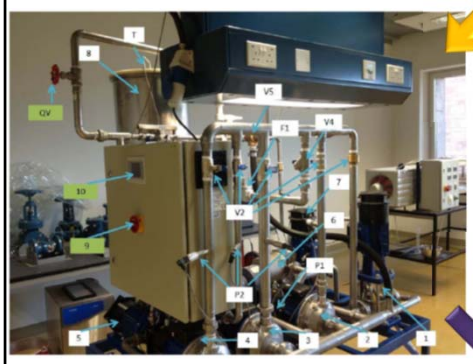
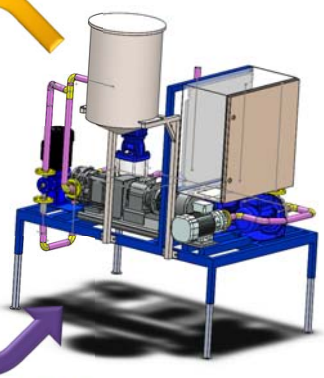
CASE II: **Mixed Reality**

Overlay the virtual on the reality





Feedback for the real to the virtual

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CASE II: **Storyline**

- ❑ A walkthrough of the user interaction with HEduART (our application)
- ❑ Parts/ Components Identification (real model, flowchart)
- ❑ Short descriptions per component, additional images/videos
  - Spatial placement of info is challenging
- ❑ Virtual Models for selected components
  - Expanded/assembly 3D models
  - Motor-animations and Sections
- ❑ Step-by-step guide of the experimental process
- ❑ Interactive Games
  - Open/close valves
  - Identify the component
  - Assemble a component or the whole flowchart

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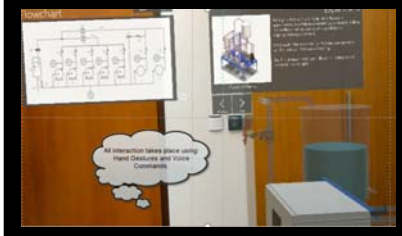
CASE II: **Testing the Holographic Application as stand alone**

Augment environment with digital boards and 3D models



On the fly labelling of important units and components

Display 3D and animated details of "hidden" structures (e.g. inside a pump)

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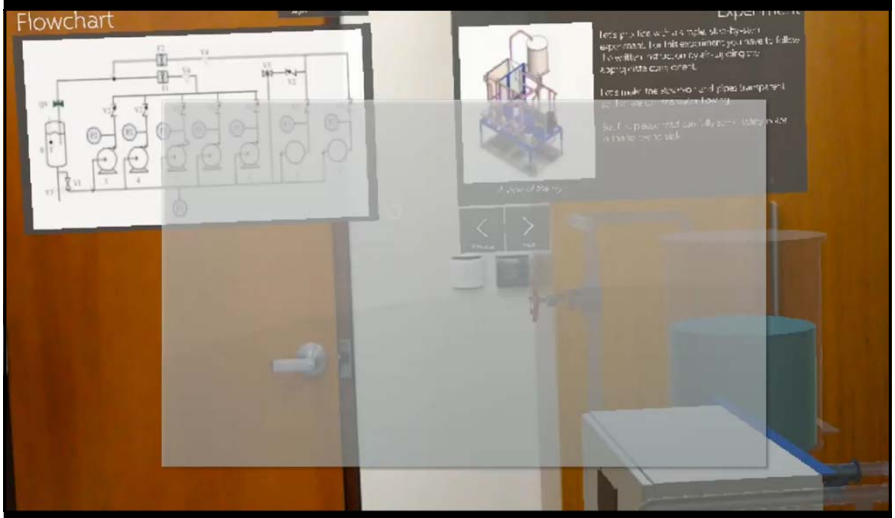

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CASE II: **Testing the Holographic Application in the lab**

Augment real environment with digital information

Overlay "hidden" details on physical objects (e.g. fluid flow in pipelines)

Simulate safety incidents and other procedures using the actual unit/tool

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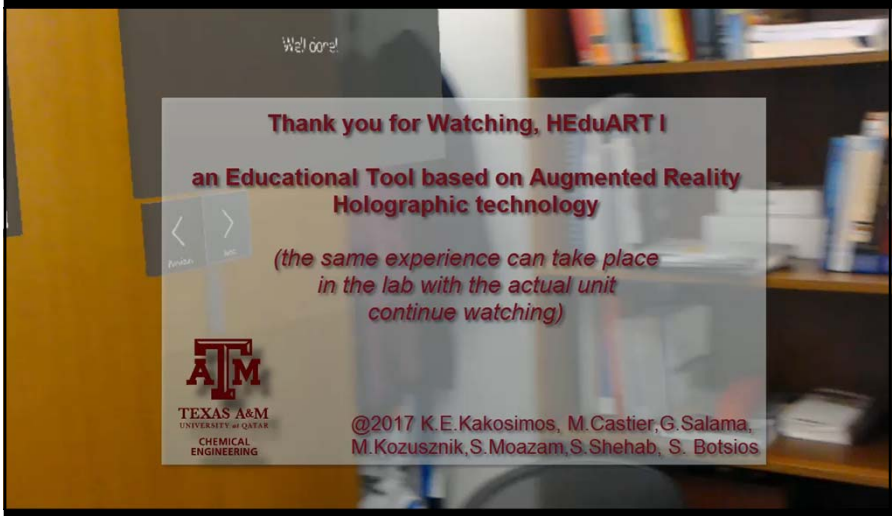
CASE II: **Testing the Holographic Application in the lab**



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CASE II: **Evaluation of the stand alone Holographic Application**

- Outline
  - ~30 students test a demo version (5' to 6' duration)
  - Assess experience and learning

✓ Pre- and Post-Quiz related to new learning
~43% improved (17% significantly, 26% marginally)

✓ Self-survey addressing learning attitude, satisfaction, cognitive accessibility, and cognitive validity
- Impressive satisfaction - significant validity,
- fair accessibility - improved attitude

✓ Selective Interviews to capture personal perspective and comments
excellent feedback, some technical comments

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CASE II: **Lessons Learned**

- Instructors / Institutions
  - Huge amount of time on learning the actual tools
  - Centralize development around individuals with creative ideas
- Students
  - Tremendous impact on the learning attitude ← **Digital Generations**
  - Indications of significant improvements…but investigation in progress
- Personal

Case 0 & I, although yielded scientific papers and **international awards** did not reach the community

Case II, follow the start-up companies paradigm

- Minimum-viable-product (HEduART)
- Open it to higher motivated people → **VertiPro startup (by a student)**
- Partner with local stakeholders for promotion & networking

Microsoft

- Flexible and "resilient" architecture

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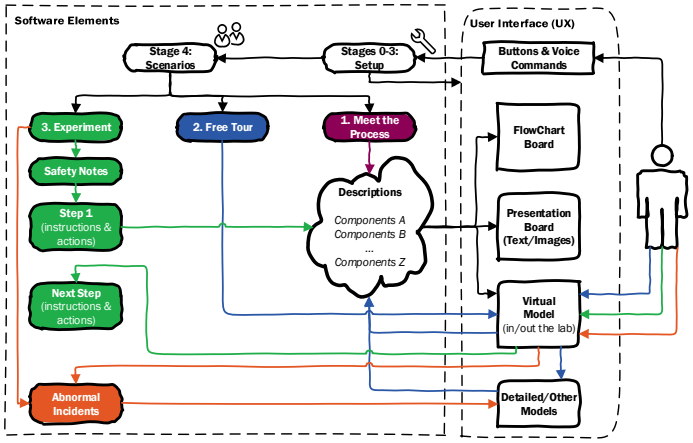
CASE II: **Lessons Learned**

- Flexible and "resilient" architecture
  (i.e. interconnected neurons/objects rather than a storyline)



White blocks and black connectors are general / Colored blocks and connectors are dedicated

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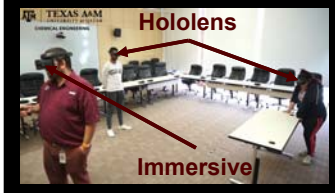
Case III: **Combine AR & VR ~ Mixed Reality**

Different Users & Devices



In the same Virtual Space

or different scales

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Case III: **Combine AR & VR ~ Mixed Reality**

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Case IV: **Augment an actual office / Classroom environment**

Address the Operational Issues of AR/VR Headsets

- ❑ Emergency responders (and other field users) need to wear AR headsets for multiple hours
- ❑ Personal Protection Equipment cannot be compromised

- ✓ An adaptor to accommodate Hololens (AR device) on a safety helmet

Designed and manufactured at TAMUQ

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More cases: **Augmenting Teaching beyond the University…**

- Smart City and Emergency Response
  - Visualize Critical Information for Planning and Decision Makers
  - Overlay information from GIS
  - Visualize simulations of hazardous events (fires, toxics)
  - Study natural disasters (dust storms, and flooding)
- Interact with equipment that you should not "full around"
  - Aircraft Engines
  - Military equipment
  - Industrial facilities
- **Aggies Mixed Reality Academy**

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Thank you

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Ευχαριστώ

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