UNIVERSITY OF NEBRASKA AT OMAHA
COLLEGE OF INFORMATION SCIENCE & TECHNOLOGY

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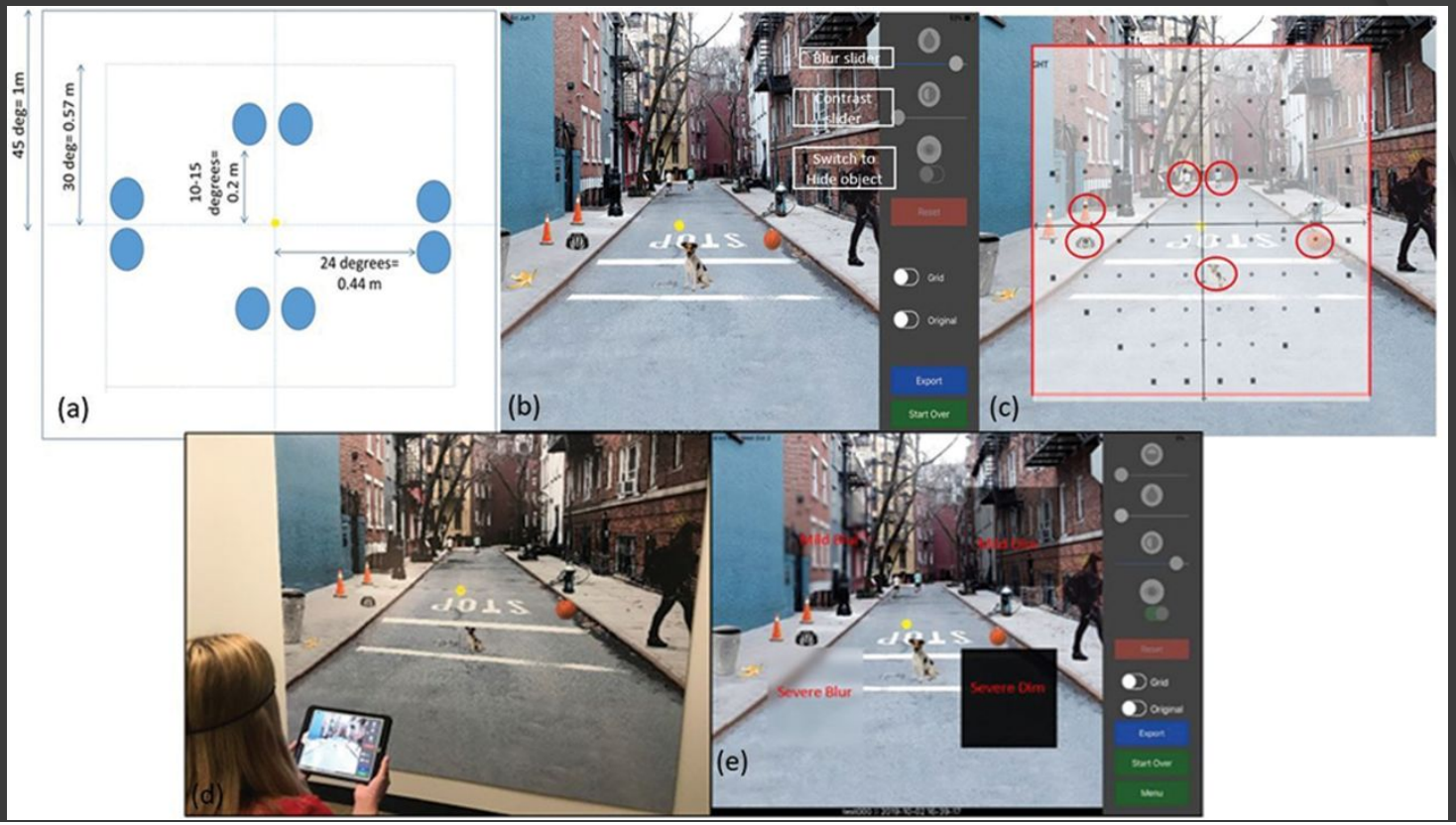
CONDUCTING MEDICAL RESEARCH USING INNOVATIVE TECHNOLOGY INTERVENTIONS AND ADVANCED ANALYTICAL TOOLS: BEST PRACTICES WITH ILLUSTRATIONS

The E-health Context

- E-Health Technologies are no longer limited to the technologically savvy. Covid-19 has in fact accelerated the pace of adoption of these technologies in behavioral & social science based medical research/practice.
  - > 3.8 billion people own a smartphone [Statista] & this is expected to further grow by several hundred million in the next few years
    - China (850 million), India (350) & the USA (260 million) have the highest number of smartphone users
  - > 79% of minority and low-income populations have smartphones [Pew Research] & nearly 83% of the same population uses smartphones as their primary means of online access at home.
  - Wearable (e.g., smartwatch devices, pedometers, heart rate monitors) are growing in availability and adoption – nearly 24% of US adults already use some type of wearable [Statista]

iPAD Glaucoma Research Study App



(A) Poster: a 2×2 m poster subtending a visual angle of 45° at 1 m was designed depicting a naturalistic street scene with a central fixation point (yellow dot) and objects of interest placed at areas of common glaucomatous visual field defect (blue dots in "a" and red circles in "c").

(B) Screenshot of iPad app: areas can be selected and modified using a sliding scale for blur & contrast. A toggle switch is used to hide an object.

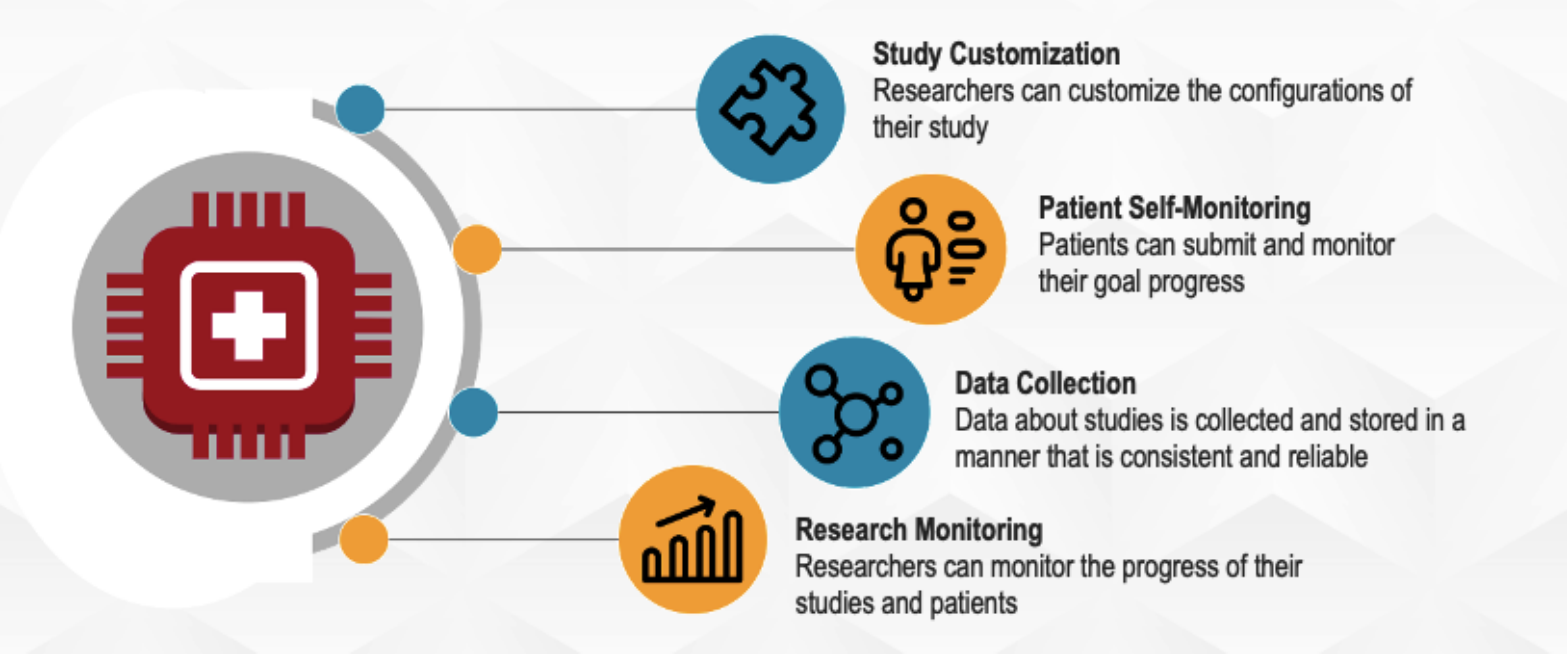
(C) Analysis: the subject response at each point on the poster corresponding to the recorded as visualised in "c".

(D) Subject compares poster with iPad image and modifies the iPad image until it matches their perception of the poster.

(E) Screenshot of iPad app showing the varying degrees of blur and dimness adjusted by the sliders present on the right.

Meghal Gagrani et al. Br J Ophthalmol doi:10.1136/bjophthalmol-2020-317034

mHealth Research Intervention Platform… (Under development at this time)



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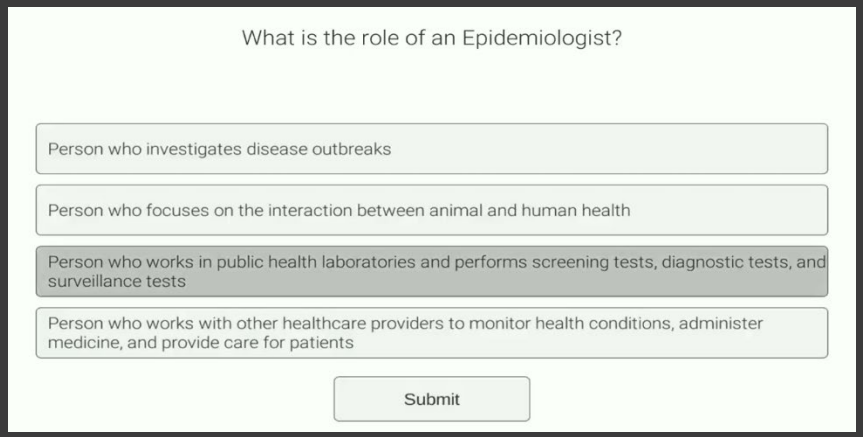
Zoodemic™



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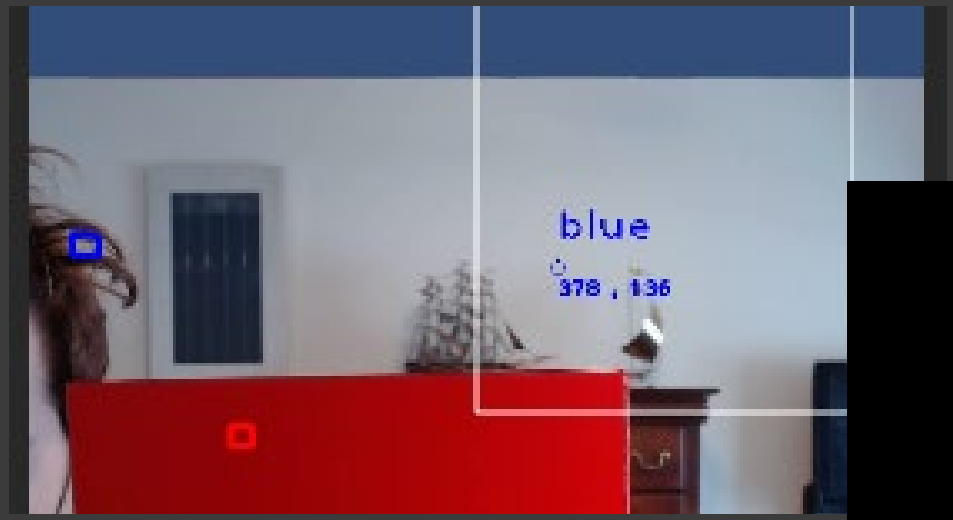
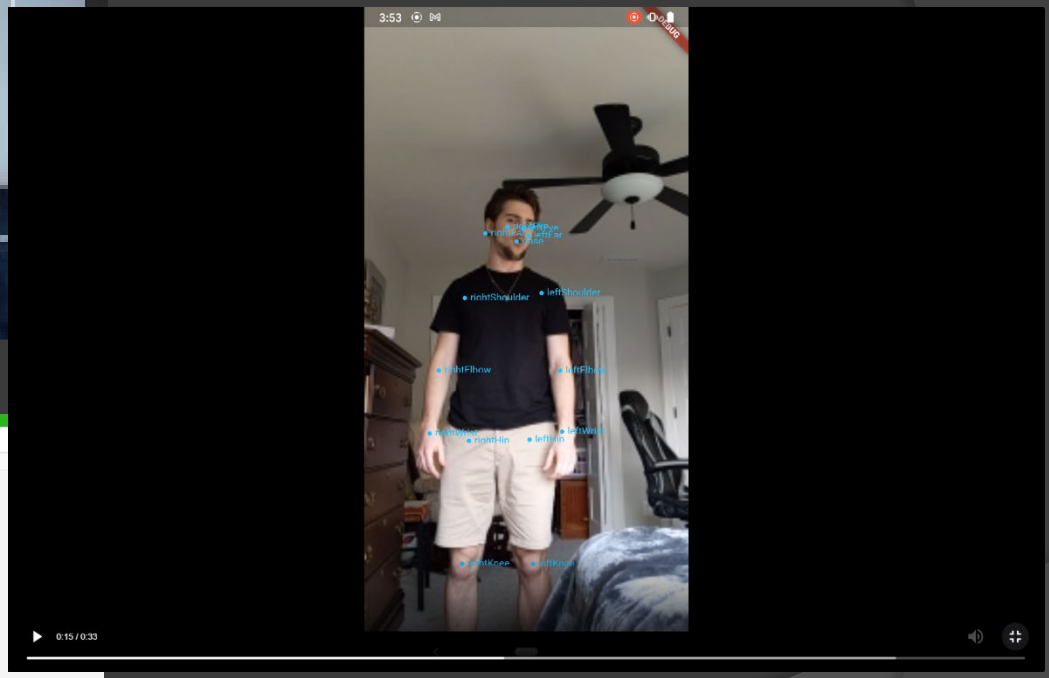
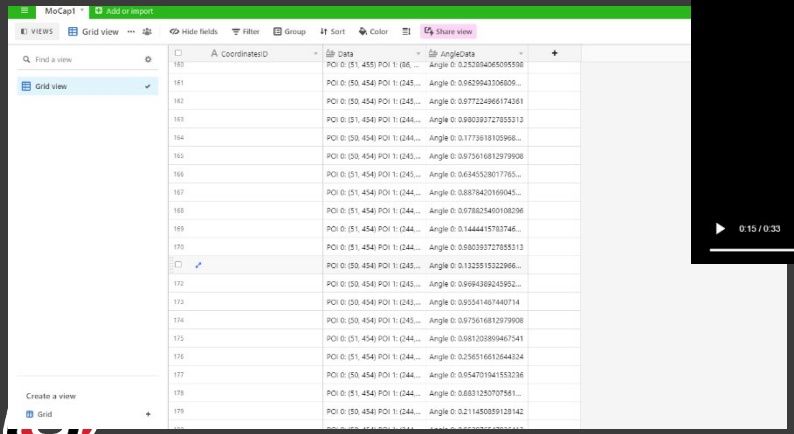
Mobility Research Apps (Currently under development)







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Building Community Health Learning Experiences in Second Life

- The purpose of this project was to create and evaluate an educational experience using Second Life
  - Create a realistic virtual home environment
  - Create an inventory of furniture, and other household goods to simulate a home for a community health home visit
  - Test the home environment for fidelity to reality with community health faculty members (face validity)

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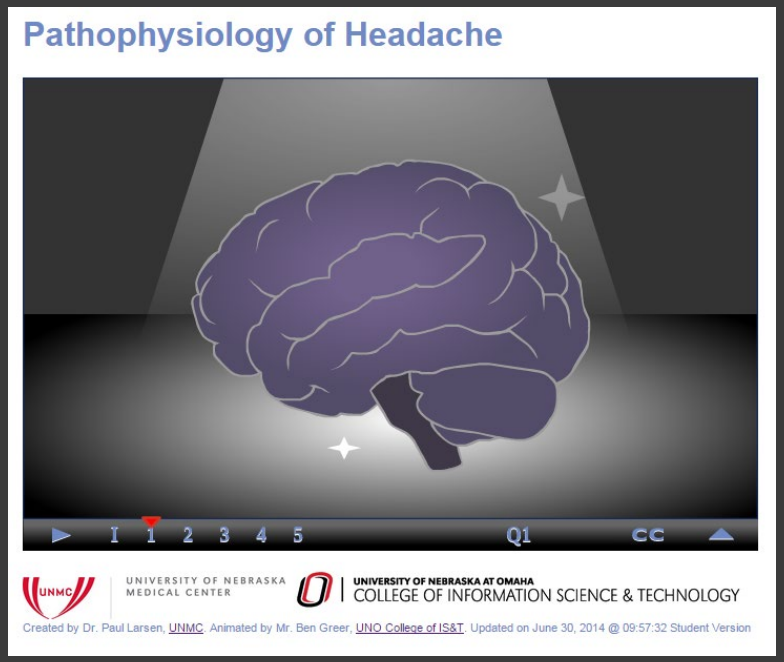
Pathophysiology of Headache Animated Lecture



- Short animations tailored to spoken lecture
- Progress is divided into units
- Questions at the end of each unit must be answered before continuing
- Alternate version created for classroom use that does not require questions to be answered

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Rheumatology Remedy Game

- Rheumatology Remedy Stand bridges the gap between required memorization of pharmacology concepts and relating them to pathophysiology and clinical presentations.
- The game's goal is to help students apply pharmacologic content to high-yield clinical scenarios in Rheumatology.
- In the game, students manage patients' acute and chronic rheumatologic complaints and get paid for their efforts.
- Rheumatology Remedy:- http://dry-harbor-21561.herokuapp.com/public/

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Gout Racer Game

- Collect “good” items for gout for higher score, avoid “bad” items for gout
  - Milk, Beer, Gout crystals, Inflamed toe, medicine
- Answer questions related to the disease
- Divided into diagnosis, etiopath, treatment, history of disease levels
- Live Site:- https://gout.ist.unomaha.community/

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Best Practices and Lessons Learned…

for Medical Science Researchers considering Technology Interventions

- Research problem to be addressed along with the question(s) and theoretical foundations in your scientific literature need to be explicit and clear to you and us
- Research design should be substantively cleaned up potentially with a paper-based pilot if needed (i.e., the research method including what the intervention is and who the subjects are or will be; data to be collected; data analysis approaches to be used and format for reporting)
- Avoid the pitfall of focusing too much on the technology solution and how it will be delivered at the outset of your research endeavor
  - Innovation in technology interventions can happen if the previous two things are clear to all of us;
  - This is our expertise ☺ both from a software engineering perspective and a research perspective in our discipline;
  - We will collaborate with you and recommend what would be ideal for your research and feasible within the budgets you may have;
  - We can also potentially collaborate on writing your grant request;
  - Even if you are going to use an off-the-shelf technology solution, we could potentially help you understand the pros and cons for your study.

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Best Practices and Lessons Learned…

- Technology based interventions and experimental treatments must be *piloted* just like any other study
- Best technology solutions as interventions are those that are simple and clear in their purpose.
- Scientific questions to consider when making a choice about using technology:
  - Is the intervention just providing an alternative (and convenient) delivery mechanism?
  - Is the technology solution additive to the efficacy of the treatment?
  - Would the technology be a potential inhibitor for the medical intervention's affect on the treatment group?
  - Have you thought about adoption and diffusion of innovation issues with the technology intervention? Is that important?

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Best Practices and Lessons Learned

- Considerations for applying AI & Machine Learning (ML) and other novel data analytic techniques in your research:
  - Problems requiring prediction, causal inference, explanation with human knowledge/expertise support,
  - Start with distinguishing between “automation problems” and “learning problems.”
    - Automation without learning is appropriate when the problem is relatively straightforward or well structured; even semi-structured.
    - Computer Vision and Machine learning, at their core, are a set of statistical methods meant to find patterns of predictability in datasets. These methods are great at determining how certain features of the data are related to the outcomes you are interested in.
  - Avoid algorithmic bias by carefully curating and labelling training data set
  - Test for efficacy of CV/ML by comparing against ground truths in the phenomenon of interest

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Our Project Intake Process

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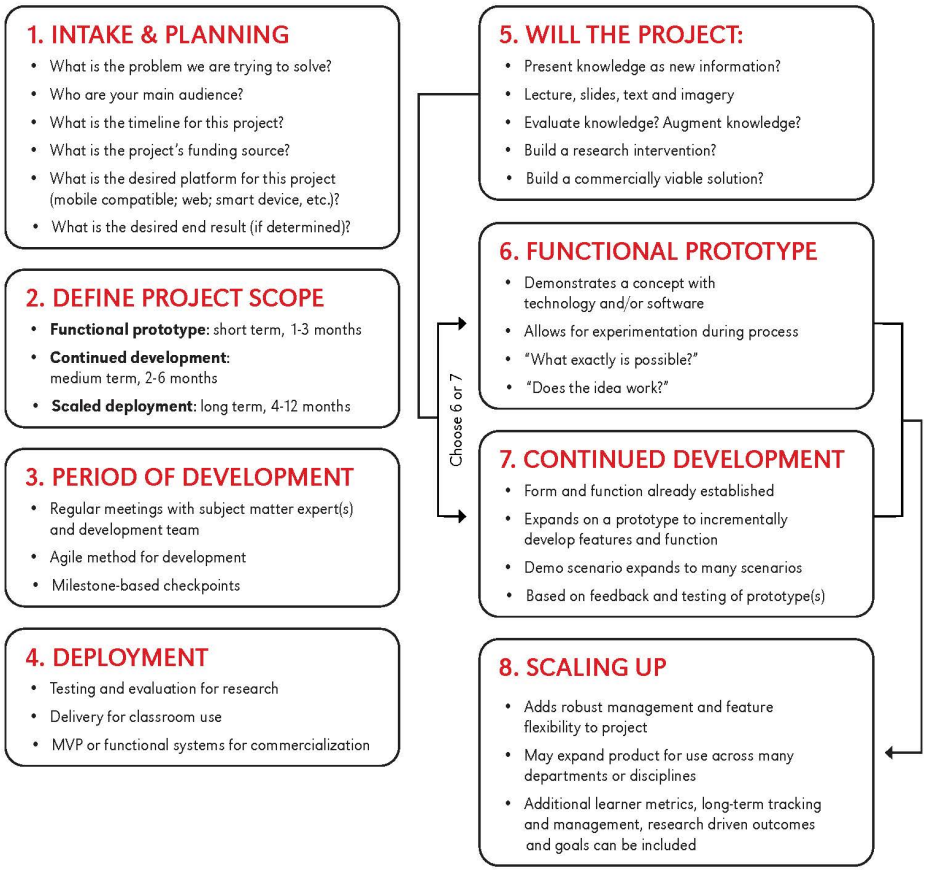

Process for Planning Projects

- Intake, Planning
  - Discuss goals of project; clarify intervention or pedagogical outcomes desired
  - Determine type of solution (we provide recommendations on the technology and the architecture)
  - Open to bleeding edge tech, innovation, experimentation, flexibility in product design/dev
- Define Project Scope
  - Functional prototype – short term, 1-3 months
  - Continued development – medium term, 2-6 months
  - Scaled deployment – long term, 4-12 months

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Process for Planning Projects

- Period of Development
  - Modified agile mindset
  - Regular meetings with subject matter expert(s) and development team
  - Milestone-based checkpoints

- Deployment
  - Testing and evaluation for research interventions
  - Cybersecurity Assessment
  - Delivery and installation on UNMC servers and/or on HIPA compliant cloud solutions

Considerations in Development

- Functional Prototype
  - Demonstrates a concept with technology and/or software
  - Allows for experimentation during process
    - “What exactly is possible?”
    - “Does the idea work?”
  - User-centered design
- Continued Development
  - Form and function already established
  - Expands on a prototype to incrementally develop features and function
    - Demo scenario expands to many scenarios
    - Based on feedback and testing of prototype(s)
- Scaling up
  - Adds robust management and feature flexibility to module
  - May expand product for use across many departments or disciplines
    - Additional learner metrics, long-term tracking and management, research driven outcomes and goals
  - May lead to commercialization

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Publications

- **Some of the work included in this presentation are based on our published research.**

  - Gagrani, M. et al. and **Khazanchi, D.** (2020; November). “What do patients with glaucoma see: A novel iPad app to improve glaucoma patient awareness of visual field loss.” *British Journal of Ophthalmology.* 0:1–5. doi:10.1136/bjophthalmol-2020-317034. (Writeup by Reuters: “New Tools Could Help Glaucoma Patients Explain Their Vision Loss” – *Medscape* – Dec 14, 2020).
  - Yu, X. and **Khazanchi, D.** (2017). “Using Embedded Mixed Methods in Studying IS Phenomenon: Risks and Practical Remedies with an Illustration.” *Communications of the Association for Information Systems:* Vol. 41, Article 2. Available at: http://aisel.aisnet.org/cais/vol41/iss1/2.
  - Owens, D., Davis, A., Murphy, J., Khazanchi, D. and Zigurs, I. (2009, March-April). "Moving First Life into Second Life: Real World Opportunities for Virtual Teams and Virtual World Project Management." *IT Professional* (an IEEE Publication), Volume 11, Issue 2, pp. 34-41.
  - Davis, A., Owens, D., Murphy, J., Khazanchi, D. and Zigurs, I. (2009, February). "Avatars, People, and Virtual Worlds: Foundations for Research in Metaverses." *Journal of the Association for Information Systems*, Volume 10, Issue 2 , Article 2, pp. 90-117.
  - Owens, D., Mitchell, A., **Khazanchi**, D. and Ilze Zigurs (2011, February). “An empirical investigation of virtual world projects and metaverse technology capabilities.” SIGMIS *Data Base for Advances in Information Systems*. 42:1, pp. 74-101.
  - Arora, V. and **Khazanchi, D.** (2010, May 21-22). “Sense of Place in Virtual World Learning Environments: A Conceptual Exploration.” *Proceedings of the Midwest Association for Information Systems Conference* (MWAIS 2010), Moorhead, Minnesota.
  - Buchanan, L. and **Khazanchi, D.** (2010). “A PDA intervention to Sustain Smoking Cessation in Clients with Socioeconomic Vulnerability.” *Western Journal of Nursing Research*, 32(3), pp. 281-304.

Discussion?

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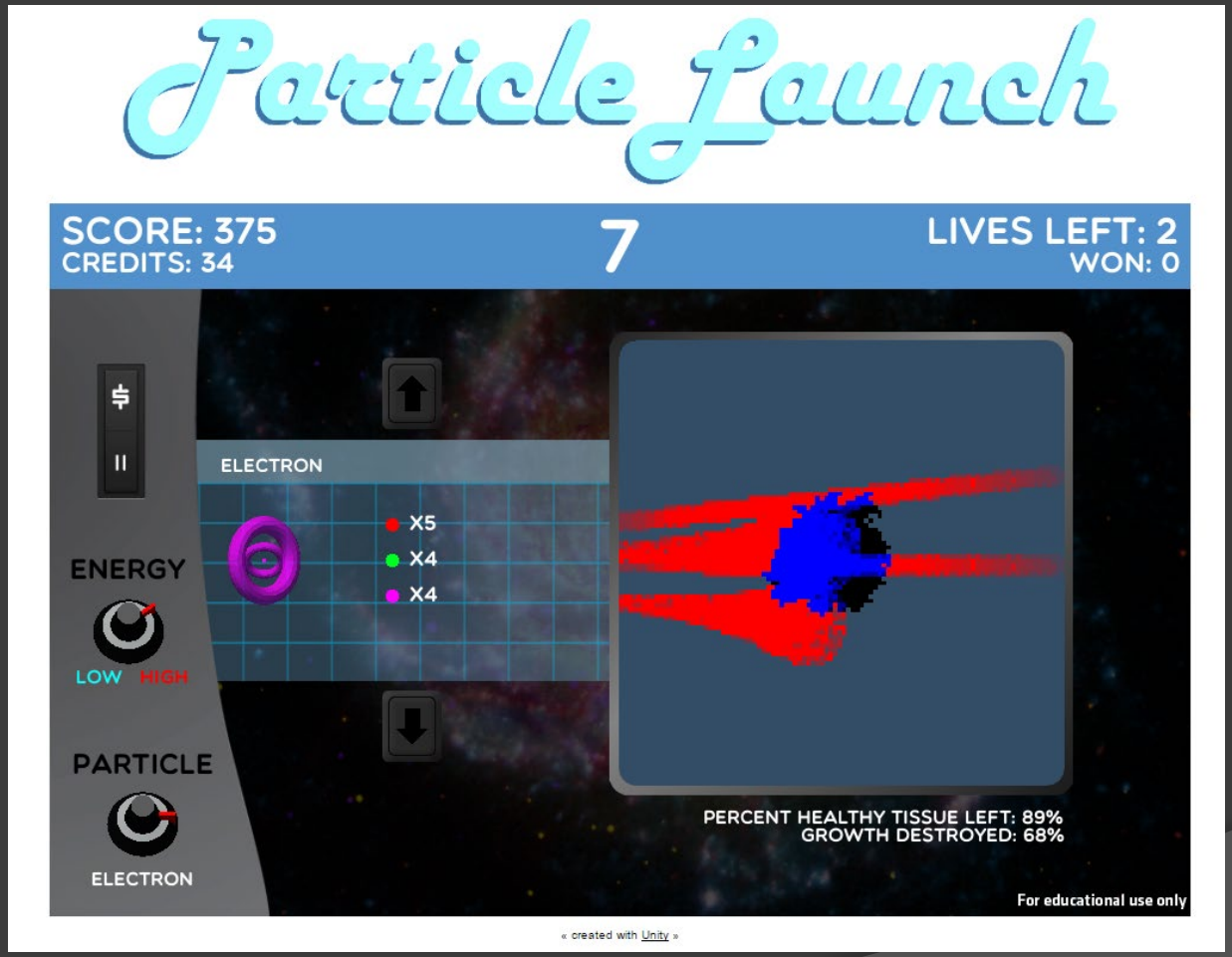
Other Illustrations

Radiation Particle Game



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Radiation Particle Game
Dr. Joseph Driewer

- Visualize how photons, protons, and electrons can be used to destroy malignant cells
- Adjust energy and angle to minimize tissue damage

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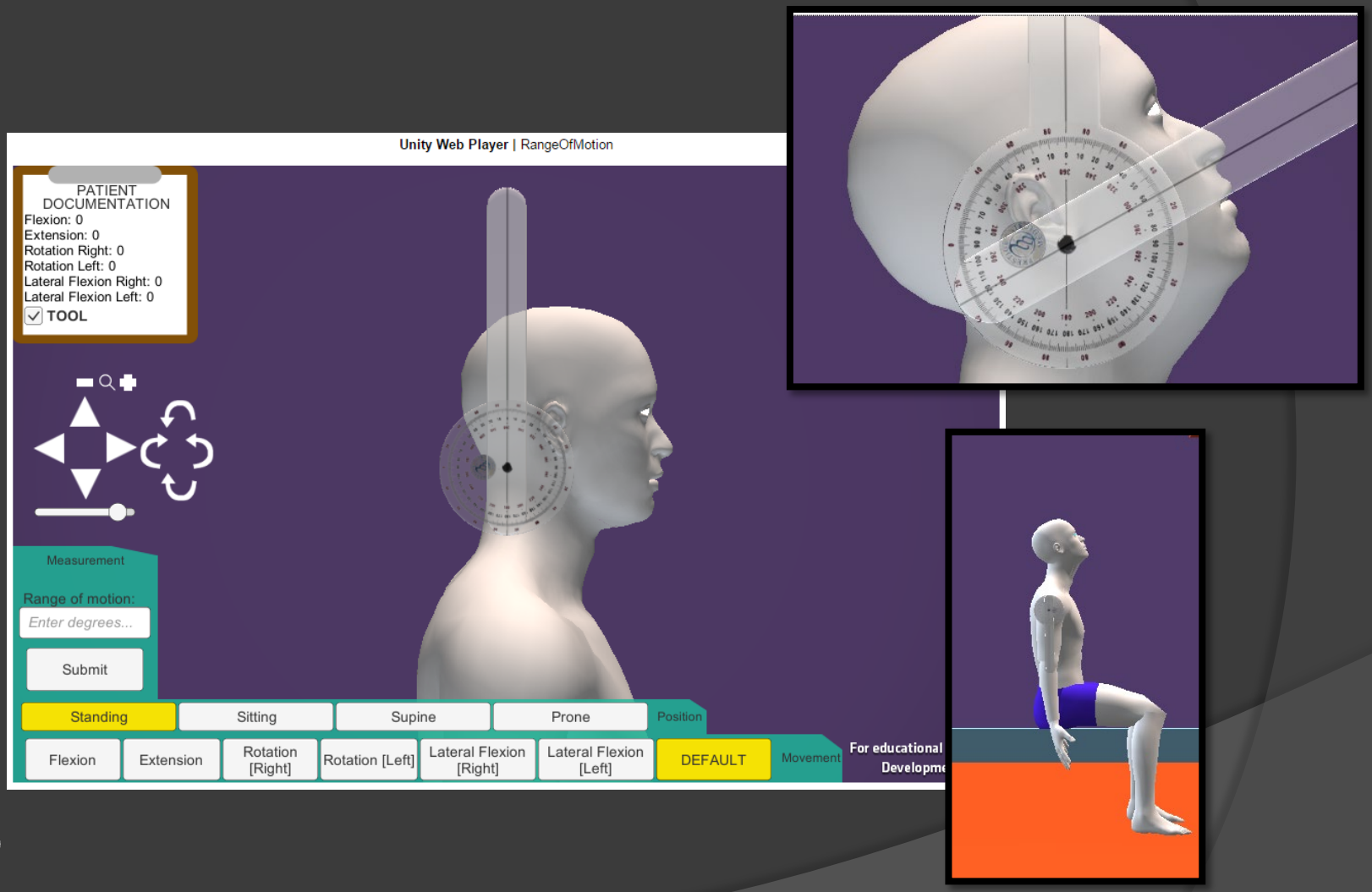
Range of Motion Measurement Simulator



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Range of Motion Measurement Simulator

- Use 3D interface to practice range of motion measurements on avatar

- Position avatar
- Position and measure with tool

- Allows measurement of head/neck movement using a goniometer
- Under development to include additional joints and tools

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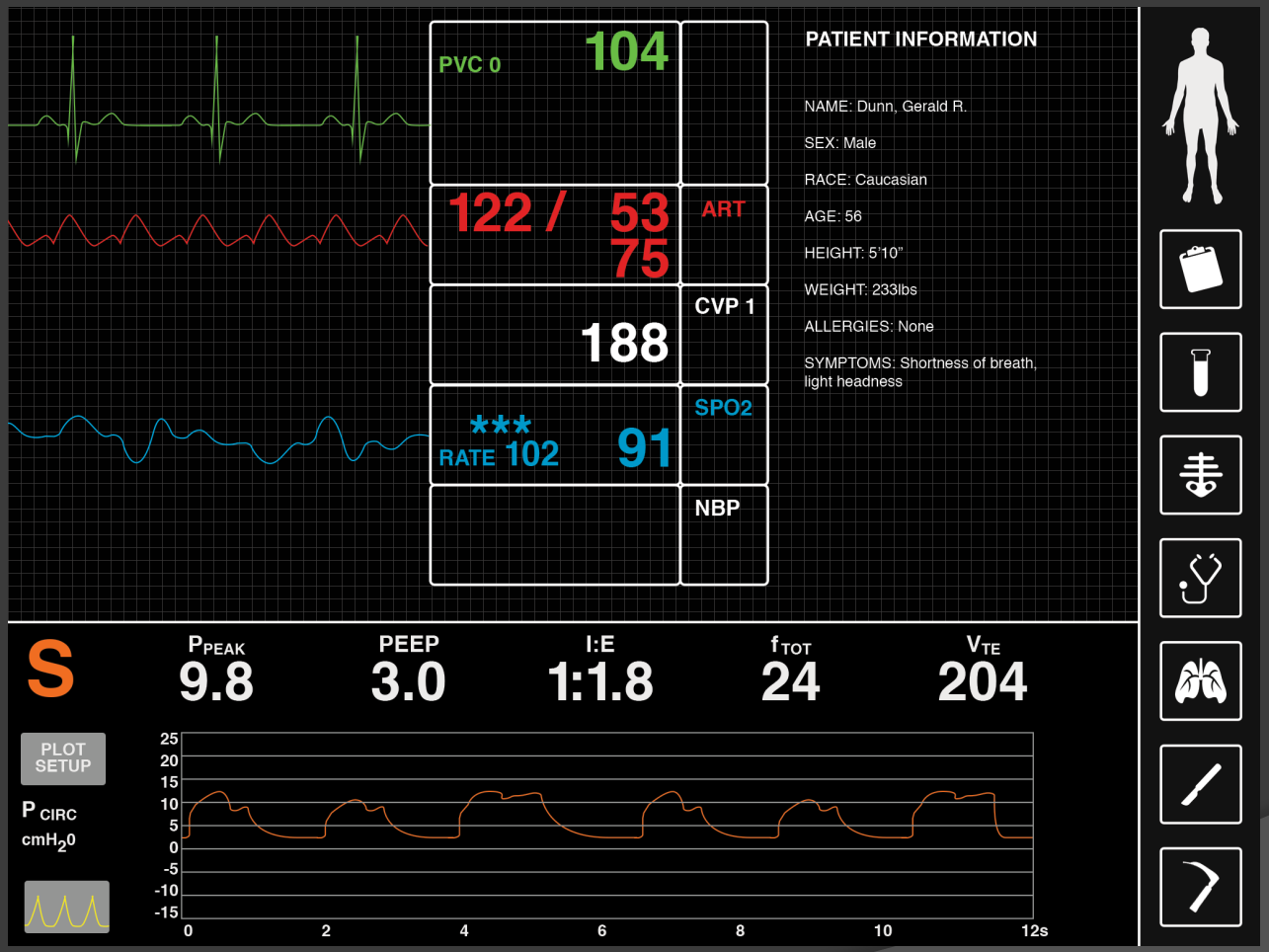
Ventilator Simulation Medical Training



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Ventilator Simulation
Dr. Charity Evans, Dr. Joseph Baus

- Decision-based sequencing as early prototype
- Patient stats react based on choices

- Exploring use of simulated lung to recreate ventilator data in module

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Considerations in Planning a Solution for Educational Use

- Will the module:
  - Present knowledge as new information?
    - Lecture, slides, text and imagery
  - Evaluate knowledge?
    - Assumes the learner has attended lecture, read the chapters, seen the slides
    - Quizzes, scenario based evaluation
  - Augment knowledge?
    - Assumes the learner has mastered some knowledge or skill; already been evaluated
    - Attempts for reinforce learning using the additional format
  - Be a combination of these?

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