Leveraging Gamification, Extended Realities (XR), Biosensors, & Artificial Intelligence (AI) to Produce Diverse, Equitable, & Inclusive, Adaptive Simulations

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LEVERAGING GAMIFICATION

- *No conflicts of interest to disclose*

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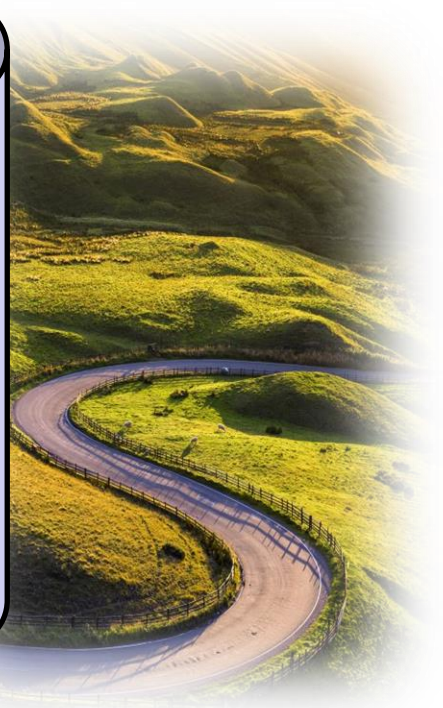
PROCLAMATION

DUE TO YOUR UNIQUE QUALIFICATIONS, YOU ARE HEREBY SUMMONED TO SERVE AS A DIVERSITY, EQUITY, & INCLUSION (DEI) CHAMPION AND COMPLETE AN EPIC JOURNEY



1) Epic Meaning & Calling
(Chou, 2019)

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Emerging technologies present creative opportunities to develop equitable, inclusive, adaptive simulation-based education to promote nursing competence associated with diversity, Equity, & Inclusion (DEI).

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There is limited research on equitable, inclusive systems that combine gamification, extended reality (XR), biosensors, and artificial intelligence (AI) to deliver adaptive simulation-based education.

Research is needed to determine effective ways to incorporate artificial intelligence (AI) in nursing education (Buchanan et al., 2021) and to implement AI technologies in health systems (Ronquillo et al., 2021).

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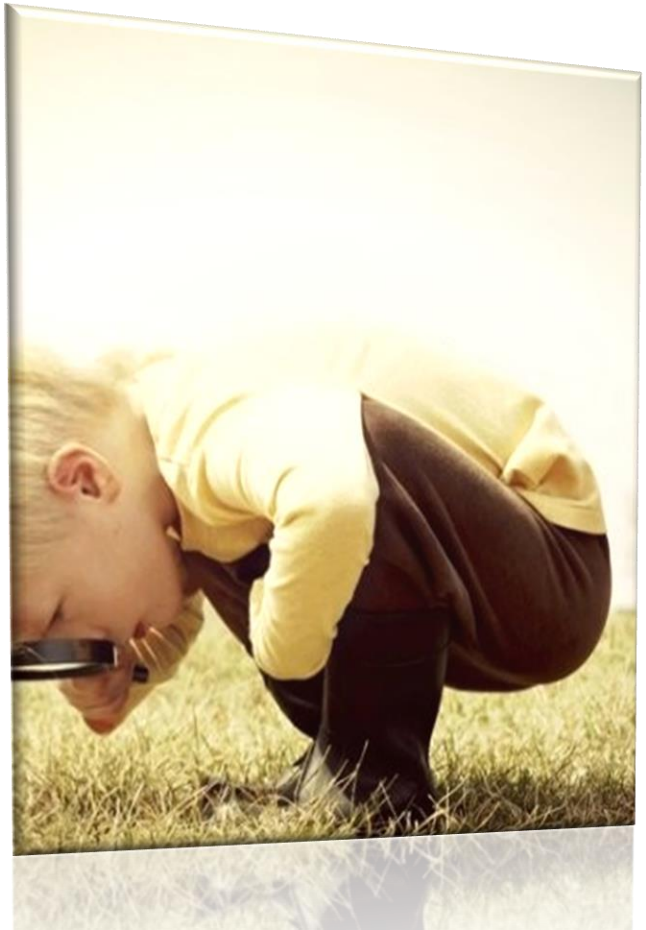

Epic Journey Purpose

- Use creativity, curiosity & limited resources to maximize DEI competence
- Learn about integration of gamification, XR, biosensors, & AI
- Identify strategies for developing diverse, equitable & inclusive simulations

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NOTIFICATION

YOU MUST GATHER KNOWLEDGE & SKILLS NEEDED TO MEET CHALLENGES & EARN REWARDS ON YOUR EPIC JOURNEY

2) Development & Accomplishment (Chou, 2019)

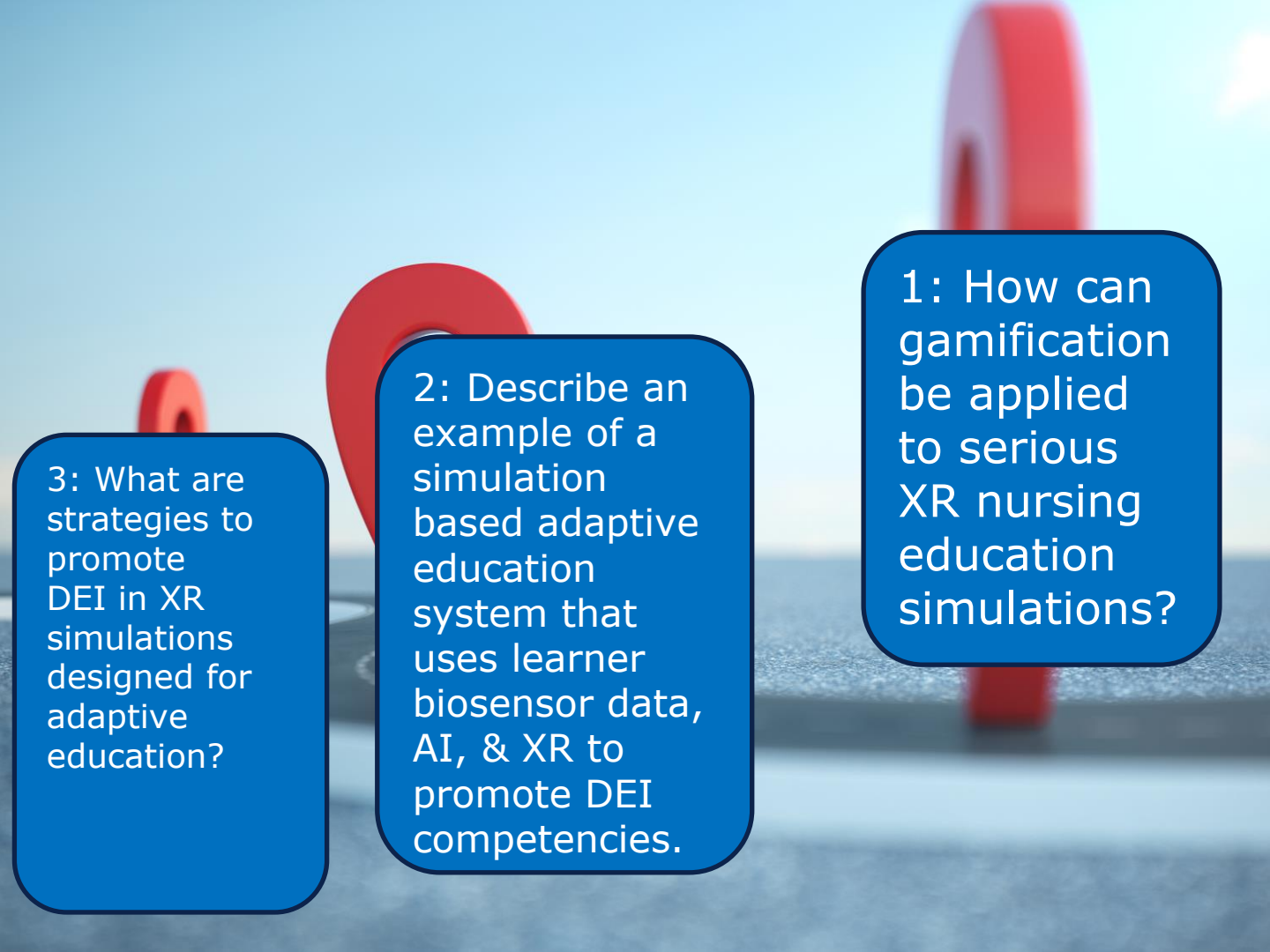
Quiz Time!

1. Do you believe you can succeed on this journey?
2. Do you value the anticipated result?
3. Do you think the cost for completing this journey is low?

Expectancy Value Theory of Motivation

- Expectation of success relates to self-efficacy
- Value of participating is held by the learner
- Resistance to active participation is low when perceived cost of participating is low

(Cooper, et al., 2017)


1: How can gamification be applied to serious XR nursing education simulations?
2: Describe an example of a simulation based adaptive education system that uses learner biosensor data, AI, & XR to promote DEI competencies.
3: What are strategies to promote DEI in XR simulations designed for adaptive education?

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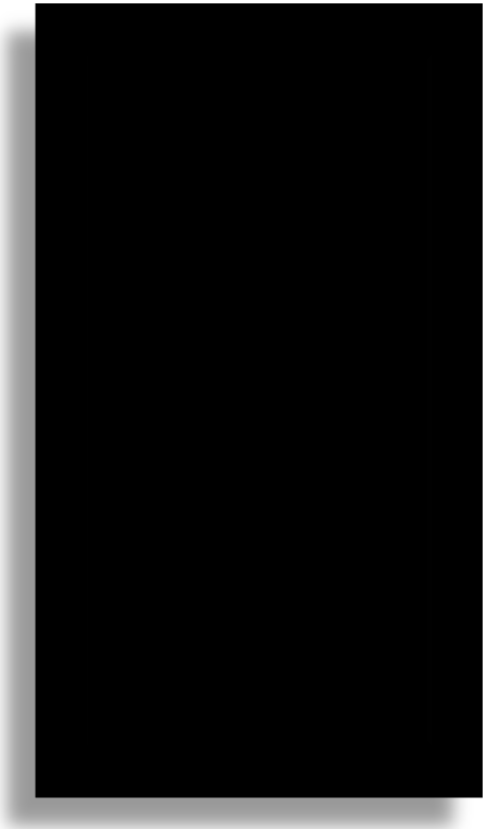
YOU ARE OFFICIALLY EMPOWERED TO USE CREATIVITY & WILL RECEIVE INSTANT FEEDBACK REGARDING YOUR PROGRESS



3) Empowerment of Creativity, & Feedback (Chou, 2019)

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"Locke and Latham (1990) have shown that feedback alone is not the cause of behavior change, it is the goals that people set in response to feedback that promote change."

(Passmore, J. & Tee, d., Eds., 2021 p. 56)

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1: How can gamification be applied to serious XR nursing education simulations?

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https://news.microsoft.com/microsoft-at-mwc19/photos/hololens-2-healthcare/

XR Simulations

- A primary goal of immersive simulation is to prepare learners to respond to real-world situations, evoking equivalent emotional responses (Pawar et al., 2018) & inducing a sense of presence in real-life like learning (Dunnigton, 2015).

- Use of XR in education can improve retention & understanding of complex concepts & can decrease the number clinical hours needed (Zweifach, et al. 2019).

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Please raise your hand if you have ever used an XR headset.

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Gamification $\neq$ **Game Theory**

$$V = \frac{A_{11} \times A_{22} - A_{12} \times A_{21}}{(A_{11} + A_{22}) - (A_{12} + A_{21})}$$

$$= \frac{9 \times 11 - 7 \times 5}{(9+11)-(7+5)}$$

$$= \frac{64}{8} = 8$$

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Effectiveness of Serious Games in Nurse Education, Systematic Review (Min, Min, & Kim, 2022)

- CINAHL, Medline, PubMed, EMBASE, PsycINFO, SCOPUS, Web of Science databases, manual search reference lists
- English & Korean between 1990 & July 2020
- Cochrane Handbook for Systematic Reviews, Cochrane risk-of-bias tools

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Effectiveness of Serious Games in Nurse Education, Systematic Review (Min, Min, & Kim, 2022) cont.

- Seven studies met inclusion criteria, most used knowledge tests, two evaluated skills performance
- Four studies reported improved knowledge & performance of nursing students & nurses
- Simple serious game technology, quizzes, competition, & time restriction can be effective

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Augmented Reality and Gamification in Education: A Systematic Literature Review of Research, Applications, and Empirical Studies

- Scrutinized literature regarding use of augmented reality & gamification in education
- Preferred Reporting Items for Systematic Reviews & Meta-Analyses (PRISMA) statement was conducted
- All types of studies for all educational stages & subjects & years were investigated
- Examined 670 articles from 5 databases (Scopus, Web of Science, Google Scholar, IEEE, and ERIC)

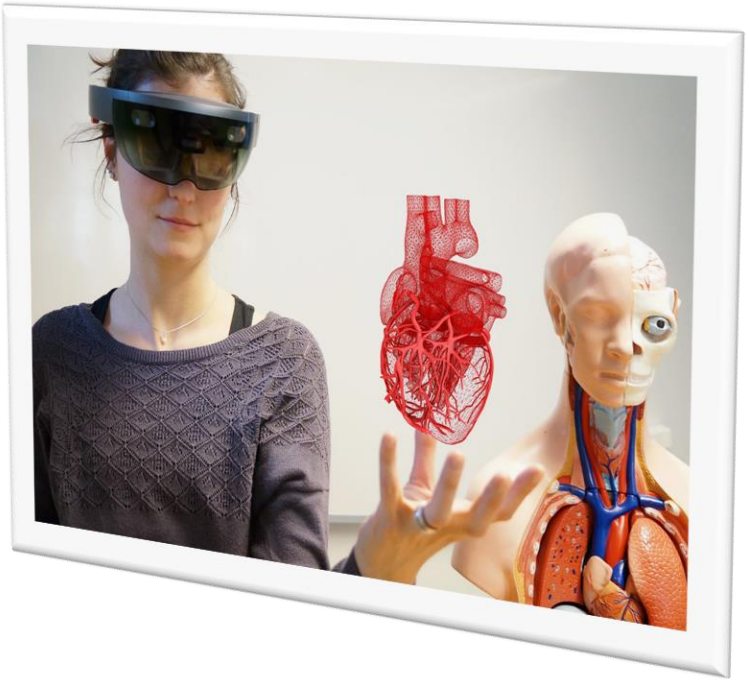
(Lampropoulos, et al., 2022)

LEVERAGING GAMIFICATION

Augmented Reality and Gamification in Education: A Systematic Literature Review of Research, Applications, and Empirical Studies (Lampropoulos, et al., 2022)

Results: Augmented reality & gamification can

- provide multiple benefits for students, assist educators, & improve educational process
- facilitate transition toward technology-enhanced learning when used in a student-centered manner, following proper education strategies & considering students' knowledge, interests, unique characteristics, & personality traits



LEVERAGING GAMIFICATION

Augmented Reality and Gamification in Education: A Systematic Literature Review of Research, Applications, and Empirical Studies (Lampropoulos, et al., 2022)

Results cont.

Students demonstrated

- positive behavioral, attitudinal, & psychological changes
- increased engagement, motivation, participation, knowledge acquisition, focus, curiosity, enjoyment, academic performance, & learning outcomes

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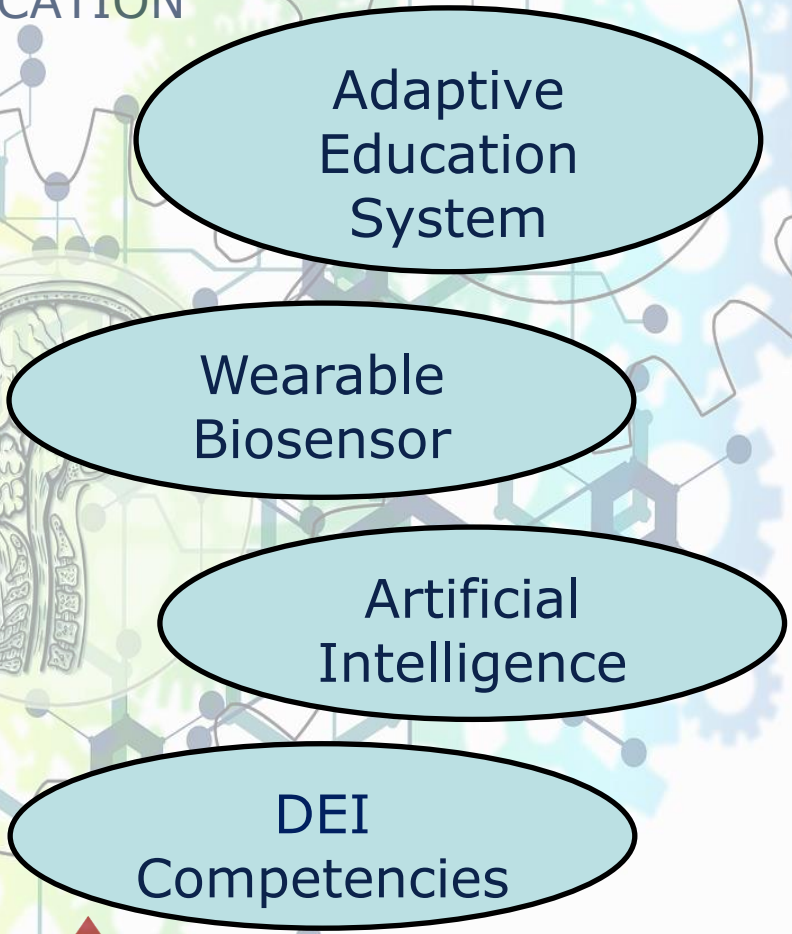
2: Describe an example of a simulation based adaptive education system that uses learner biosensor data, AI, & XR to promote DEI competencies.



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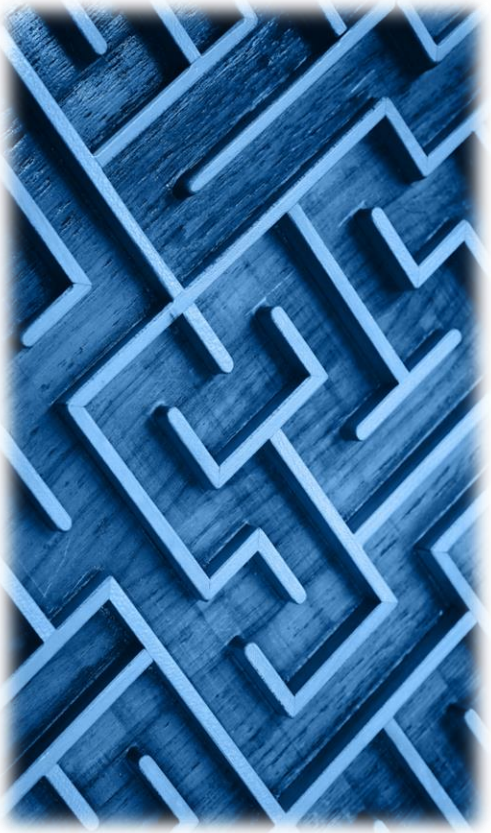
PROBLEMS

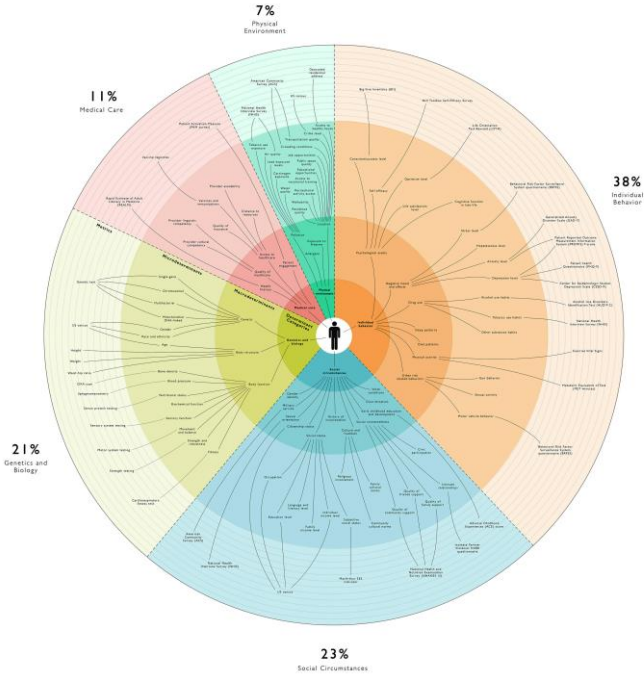
- Medical errors were estimated to be the third most common cause of death (Makary & Michael, 2016)
- COVID-19 was the number one cause of death in 2021 (Cox & Amin 2021)
- Gunderson & Rodwin (2020) reported less than 5% of hospital deaths are judged preventable & challenged Makary & Michael's estimates
- Errors most attributed to new nurses involve medications, treatment delays, and failure to rescue (Gaffney, et al., 2016; Hall, et al, 2020; Saintsing, et al., 2011)



LEVERAGING GAMIFICATION

PROBLEMS

- Nursing programs have not mastered how to prepare students to engage with their communities through understanding social determinants of health (SDOH) and underlying root causes of structural racism linked to health inequities (Wakefield, et al. 2021).



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PROBLEMS

- Gaps in training result in difficulties providing safe & effective patient care in complex systems.
- Gaps contribute to workforce instability as new graduate nurses leave the profession soon after graduation (AlMekkawi, & El Khalil 2020).
- More than 1/3rd of newly licensed nurses leave the profession within the first two years as they are not prepared for the realities of practice (Flinkman, et al. 2013; Robert Wood Johnson Foundation, 2014).

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PROBLEMS

- A systematic literature review of clinical education & student learning outcomes was declared an "empty review" as no valid & reliable tools for assessing clinical outcomes in prelicensure nursing programs were found (Leighton et al., 2021).

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NOTICE

THERE ARE 5 CHANCES TO OBTAIN A FREE CONSULT. APPOINTMENTS WILL NOT BE CONFIRMED UNTIL 2 DAYS AFTER REQUEST IS SUBMITTED.

6) Scarcity & Impatience

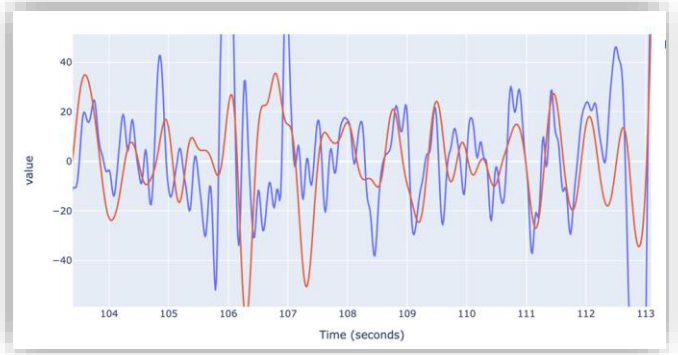
(Chou, 2019)

Sensors, Stress, Workload, & Situation Awareness

Physiological measurement techniques for quantifying task load, effort, performance, & stress include EEG, eye-tracking, heart rate/heart rate variability, galvanic skin response, and others have been employed (Antoniou et al. 2020; Karwowski, 2012; Hogervorst et al., 2014).

Sensors, Stress, Workload, & Situation Awareness

- Heart rate variability or beat-to-beat changes, reflect sympathetic/parasympathetic balance was evaluated in relation to stress loads in simulation, burnout, & Post-Traumatic Stress Disorder (Kovesdi, 2015).
- Electrodermal activity (EDA) is a widely used response that reflects the autonomic nervous system and is a measure for stress and cognitive load (Smets, 2018).



Sensors, Stress, Workload, & Situation Awareness

- Visual attention is important for SA & decision-making (Law et al., 2018)
- Eye tracking could provide objective & more sensitive insights on human factors & SA in simulated medical emergency situations than traditional questionnaires (Desvergez et al., 2019)

Sensors, Stress, Workload, & Situation Awareness

- Henrie et al. (2015) reviewed 407 articles to verify methods for measuring student engagement in technology-mediated learning. A key dimension was emotional engagement. The authors found two main techniques to measure emotions: surveys & physiological sensors.

- Comprehension of a nursing student's learning experience through the lens of physiological responses using a combination of wearables, performance measures, & surveys is expected to improve education outcomes that translate to clinical settings.

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ENVISION
ENGAGE
INNOVATE

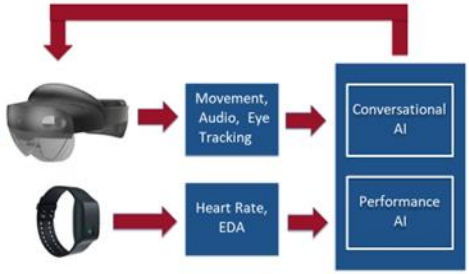
Intelligent Simulation Environment (ISE)

Integrating Sensors, Mixed Reality (MR) and Artificial Intelligence (AI) to Escalate and Validate Complex Adaptive Competencies (CAC)

Clinical Learning Activity

Beatrice Sanders, an older adult female, admitted to a hospital for a surgical procedure, is complaining of stomach pain and nausea. In this scenario, IV fluids are running at half the ordered rate and the patient's nasogastric (NG) tube is clamped. It is the task of the student nurse to identify these issues and correct them by following the established protocols.

Simulation



Project Roadmap

College of Nursing (CON)

- Janine Hinton, PhD, RN, CHSE
- David Celaya-Gonzalez, MS
- Tarnia Newton, DNP, FNP-C
- Steve Machtley
- Connie Miller, DNP, RN, CNE

Systems & Industrial Engineering (SIE)

- Young-Jun Son, PhD
- Yijie Chen, Doctoral Student
- Tariq Islam, Doctoral Student
- Kamelia Sepanloo, Doctoral Student

Center for Digital Humanities (CDH)

- Bryan Carter, PhD
- Gabrielle Lampner, Undergraduate Student
- Ishika Patel, Undergraduate Student
- Daniel Shevelev, Undergraduate Student
- Nate Teku, Undergraduate Student

Learn more at https://www.nursing.arizona.edu/cnd

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Intelligent Simulation Environment (ISE) and Adaptive Precision Education (APE): Integrating Sensors, Virtual and Mixed Reality and Artificial Intelligence to Escalate and Validate Complex Adaptive Competencies (Hinton et al., 2023)

- The ISE was designed to address training gaps & improve complex adaptive competencies (CAC) to increase situation awareness (SA), safety & reduce errors.

CACs involve the ability to successfully and efficiently provide evidence based safe and value-added patient centered care based on individual and/or team divergent non-linear clinical decision making. This decision-making process requires seeking, synthesizing, and adapting information from multiple sources that best serves a specific dynamic context (Hinton, 2020)

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ISE & APE in Healthcare Pilot

(Hinton et al., 2023)

- Multiple physiological, objective, & subjective measurement techniques for quantifying task load, effort, performance, & stress
- Biosensors: eye-tracking, heart rate/heart rate variability, & electrodermal activity

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ISE & APE in Healthcare Pilot
(Hinton et al., 2023)

Test, improve & further develop the prototype ISE & healthcare simulation scenarios in order to

1) Develop the ISE for use in larger research studies

2) Evaluate the feasibility & acceptability of using the ISE with simulation scenarios from student & faculty participants

3) Determine the number of participants needed for a larger study & a well-developed dataset, which can differentiate expert level, communication & performance errors

4) Evaluate the current experimental procedures

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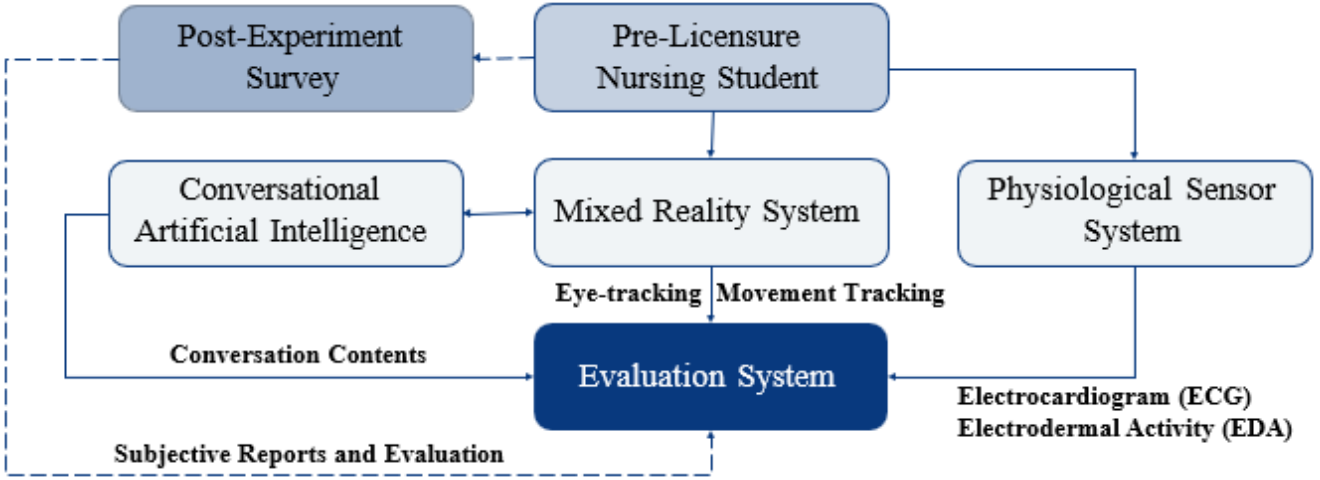
Mixed-Reality-based Interactive Nursing Training System Integrated with Artificial Intelligence: Realistic Training, Objective Evaluation, and Cognitive Activity Analysis (Chen et al., 2022)

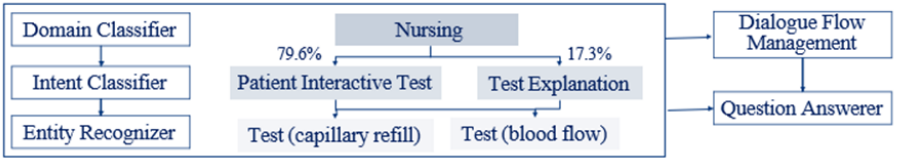


Mixed-Reality-based Interactive Nursing Training System Integrated with Artificial Intelligence: Realistic Training, Objective Evaluation, and Cognitive Activity Analysis (Chen et al., 2022)

❖ **System Platform and Functions**

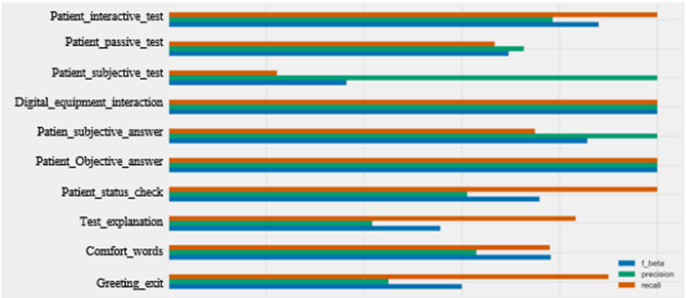
- MindMeld platform (Python 3.6 or 3.7), open-source
- Question understanding, Answer Generation, Question Evaluation, and Communication with MR system

a) Alright, I am going to check your capillary refill here, to see how good your blood flow is.
b) Do you feel pain on your back?
c) Can you give a number on that pain between 0 to 10? 0 means ok and 10 means the worst possible pain. (Please describe 0 or your ok level for me)



Model Performance

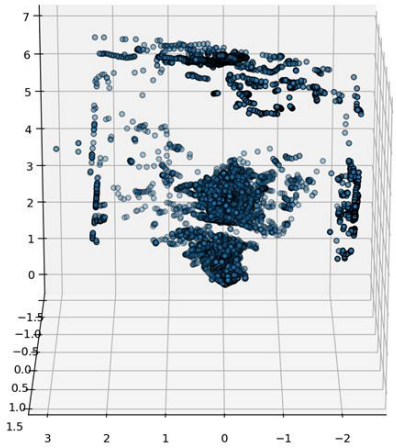
- Best Accuracy: 79.44%
- Multi-labeling
- Bag of Words: (1, 5)
- Model Type: Decision tree



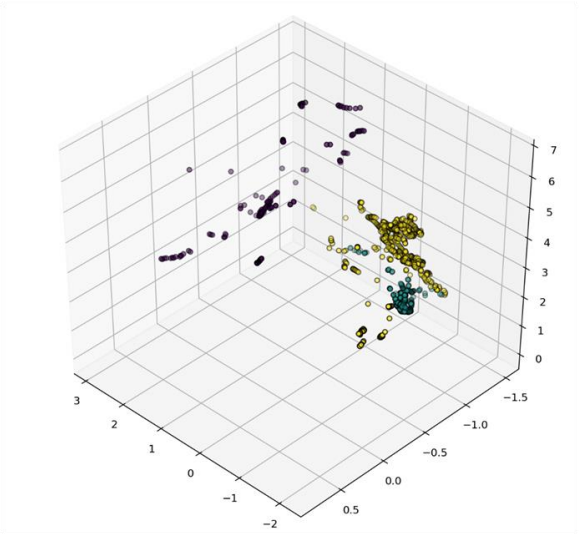
Intent Classifier Performance Evaluation Metrics

ISE & APE in Healthcare Pilot

Eye Tracking Example



a. Raw data mapping of gaze point for 1 minute nurse interaction with patient



b. K-mean clustering result based on raw data in a.

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WHAT'S NEXT?

CAN YOU PREDICT WHAT ELSE YOU WILL LEARN? ARE YOU CURIOUS ABOUT HOW YOUR EPIC JOURNEY WILL END?

7) Unpredictability & Curiosity (Chou, 2019)

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ISE & APE in Healthcare Pilot
(Hinton et al., 2023)

Learner Performance & ISE Evaluation

Qualitative Methods

1) Progress records and reports
2) Think-aloud pauses
3) Written responses to open ended debrief questions, ISE Debrief

Quantitative Methods

1) Situation Awareness Global Assessment Technique (SAGAT) (Endsley & Garland 2000) scenario freeze questions
2) Nursing Performance Profile 5-Factor instrument (Hinton, et al., 2020)
3) NASA task load index (Hart 2006)
4) Mixed Reality Experience survey

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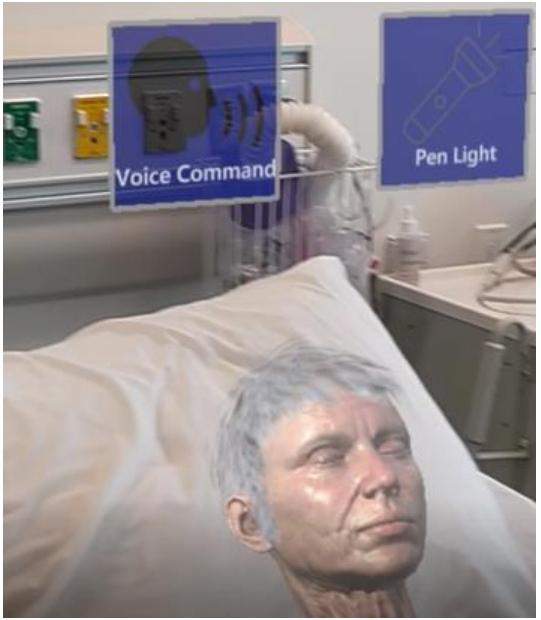
ISE & APE in Healthcare Pilot
(Hinton et al., 2023)



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ISE & APE in Healthcare Pilot
(Hinton et al., 2023)

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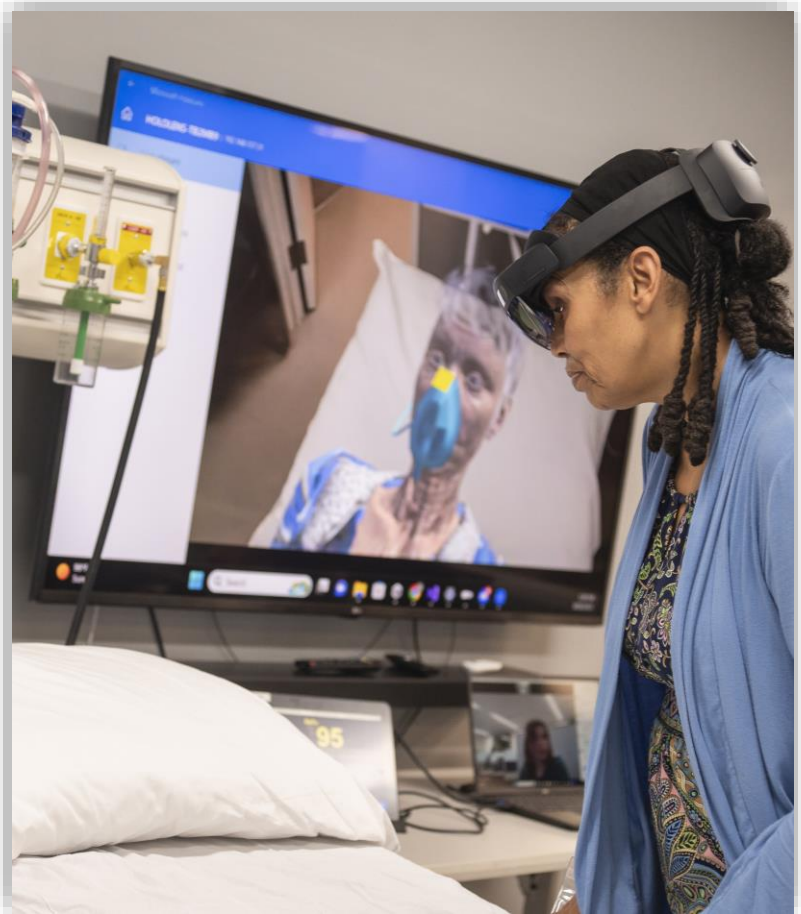

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ISE & APE in Healthcare Pilot
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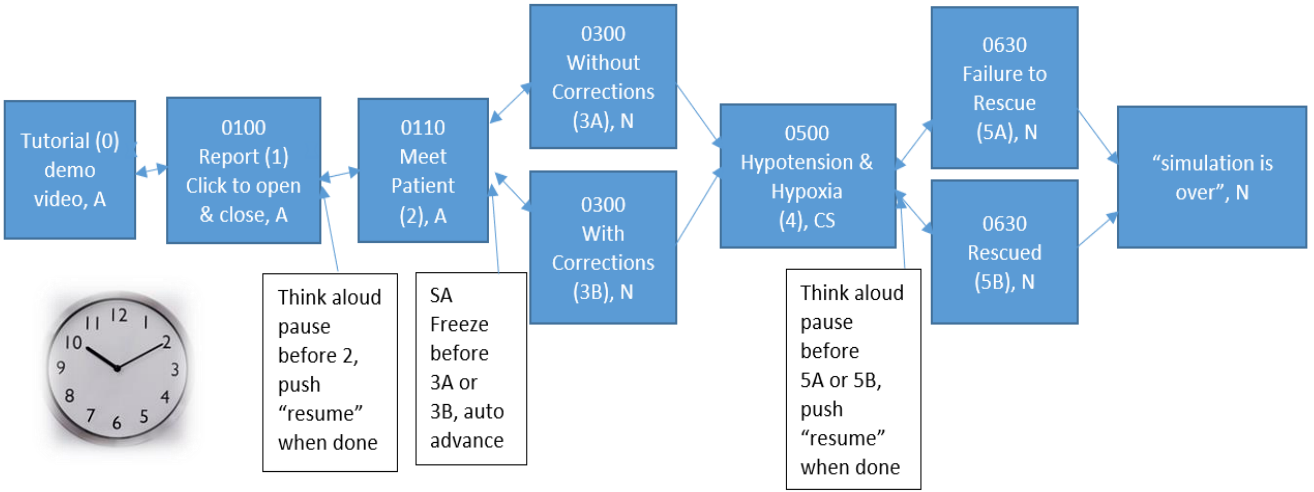

A = Always selectable
CS = Conditionally selectable, only after completing segment that follows (after 5A or 5B)
N = Not selectable

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ISE & APE in Healthcare Pilot (Hinton et al., 2023)

Adaptation

- Conversational AI continuously adapts patient responses based precisely on learner's statements
- Patient outcomes dependent on learner actions or inactions & time segment

Future: Adjust pace, complexity, cues, &/or resources based on real-time individual learner's biosensor data & performance to promote expert level CACs.

ISE & APE in Healthcare Pilot: GAMIFICATION

(Hinton et al., 2023)

1. **Meaning:** Responsible for caring for Beatrice and keeping her safe

2. **Accomplishment:** Challenges include finding and correcting errors. Identifying and responding properly in a timely manner to deterioration due to sepsis.

3. **Empowerment:** Multiple tools for completing assessments in order of learner's choosing. Multiple treatment options to select from in rapid response orders. Time travel options.

4. **Ownership:** Research thank you letter and inclusion of volunteerism on resume. Gift card for participation.

5. **Social Influence**: Being helpful to Beatrice. In the future, being part of a team (multi-player) version of the scenario.

6. **Scarcity:** Time limits & pressure. Other members of the health team can only be communicated with by leaving verbal message.

7. **Unpredictability:** Cannot find out what happens next without completing next segments of the scenario.

8. **Avoidance:** Keeping Beatrice from being harmed or dying. Not wanting to appear incompetent.

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URGENT

AVOID LOSING WHAT YOU LEARN! ACT QUICKLY! DECIDE HOW YOU WILL USE GAMIFICATION IN YOUR NEXT INNOVATION!

8) Loss & Avoidance (Chou, 2019)

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Review the list as it appears below and hold up the number of fingers that represents the total number of items in the list that would motivate you to act immediately:

- 50% discount on a dream cruise, offer expires in 2 hours.
- Open ended invitation to go to lunch with an old friend that you see often.
- Professional license that will expire at midnight if not renewed.
- A patient you are caring for accidentally removed their IV.

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Diversity

Equity

Inclusion

3: What are strategies that can promote diversity, equity, & inclusion in XR simulations designed for adaptive precision education?

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Diversity: range of "individual, population, and social characteristics, including but not limited to age; sex; race; ethnicity; sexual orientation; gender identity; family structures; geographic locations; national origin; immigrants and refugees; language; physical functional, and learning abilities; religious beliefs; and socioeconomic status" (AACN, 2017, p.1)

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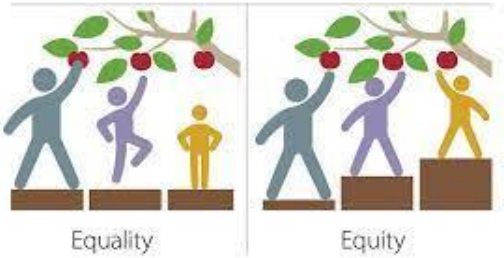
Equity



Educational Equity:

Each learner receives what they need to develop to their full social and academic protentional.

(National Equity Project)

Healthcare Equity:

Fair and just opportunity for everyone to attain their highest level of health. Requires ongoing efforts to address social and economic obstacles to healthcare.

(Braveman et al. 2017, Healthy People 2020)

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Inclusion: An environment & organizational culture that intentionally embraces, welcomes, respects, & acknowledges diverse perspectives & in which all individuals thrive.

(AACN, 2017)

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- Nursing is a relational profession with a social contract to serve society, adhere to a professional code of ethics, regulatory licensure, institutional policies, and global expectations (Fowler, 2015)
- Simulation-based education can be leveraged to teach essential behavioral skills to reduce bias & promote Diversity, Equity & Inclusion (Daya et al., 2022)

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INVITATION

YOU ARE ENCOURAGED TO INCLUDE MENTORS & NEW COLLOGUES ON YOUR EPIC JOURNEY

5) Social Influence & Relatedness (Chou, 2019)

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A Scoping Review of the Priority of Diversity, Inclusion, and Equity in Health Care Simulation
(Smallheer et al., 2022)

Theoretical Framework:
Cultural Humility

Principles: "(a) life-long learning and critical self-reflection, (b) recognition of and compensation for power imbalances in the provider-patient relationship, and (c) institutional accountability to students, staff, faculty, patients, and communities (Tervalon & Murray-Garcia, 1998).(Smallheer et al., 2022 p. 43)"

A Scoping Review of the Priority of Diversity, Inclusion, and Equity in Health Care Simulation
(Smallheer et al., 2022)

Research Questions:

"1. What concepts of DEI are evident in health care simulation literature based on publication dates prior to 2018 compared to literature published after 2018?

2. What recommendations are available in the published literature for the promotion of DEI in health care simulation development and execution prior to 2018 compared to after 2018? (p. 43)"

LEVERAGING GAMIFICATION

A Scoping Review of the Priority of Diversity, Inclusion, and Equity in Health Care Simulation
(Smallheer et al., 2022)

Method:

- Arksey and O'Malley (2005) scoping review framework
- Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA)

Inclusion criteria: (a) publications in English (b) published in a peer-reviewed journal.

LEVERAGING GAMIFICATION

A Scoping Review of the Priority of Diversity, Inclusion, and Equity in Health Care Simulation
(Smallheer et al., 2022)

Results: 663 published works resulted from the search strategy; 51 articles were ultimately reviewed; 17 prior to 2018 & 34 after 2018.

Literature prior to 2018 revealed three common themes: 1. Education, 2. Cultural humility, 3. Communication

Suggestions in the literature involved self-reflection, panel discussion, manuscript writing, training, or simulations to address bias, racism, classism, homophobia, and/or sensitivity to transgender healthcare

A Scoping Review of the Priority of Diversity, Inclusion, and Equity in Health Care Simulation
(Smallheer et al., 2022)

Results cont. Literature after 2018 revealed three common themes: 1. Simulation design, 2. Simulation equipment, 3. Simulation environment.

Design:

- Portray people in a realistic, sensitive, & respectful manner.
- Carefully consider simulations that portray underrepresented, vulnerable, or exploited groups including behaviors & mannerisms; the person representing the patient should prevent stereotyping & "sameness".
- Provide opportunities to observe & engage in conversations which avoid heteronormative language, model best practices, and address implicit and cognitive bias.

LEVERAGING GAMIFICATION

A Scoping Review of the Priority of Diversity, Inclusion, and Equity in Health Care Simulation
(Smallheer et al., 2022)

Design cont.

- Design for standardized or virtual patients to provide experiences learners may not otherwise have during clinical rotations

Equipment:

- Currently manufactured simulators provide little or low representation for communities of color with unrealistic colors & little variation in hair, nail beds, soles of the feet, & palms of the hands
- Lack of physical & psychological fidelity negatively impacts learning experiences

A Scoping Review of the Priority of Diversity, Inclusion, and Equity in Health Care Simulation
(Smallheer et al., 2022)

Environment:

The educational environment should be diverse, challenge stereotypes, and provide opportunities for diverse groups to learn from and with each other

Checklist for Constructing Equitable, Diverse, and Inclusive Simulation Experiences (Craig et al., 2022)

1. "Does the scenario align with the curriculum and course objectives appropriately?"
2. "Does the prework align with the learning objectives of the scenario?"
3. "Does the simulation facilitator guide demonstrate psychological safety including key points for the prebrief and debrief?"
4. "Is this scenario free from stereotypes, -isms, or tropes with bias?"
5. "Does this simulation scenario fill a gap in training health care students to care for a diverse population beyond client care experiences available in the clinical setting?"

AACN Essentials
Domain 3: Population Health

3.1 Manage population health.

3.2 Engage in effective partnerships.

3.3 Consider the socioeconomic impact of the delivery of health care.

3.4 Advance equitable population health policy.

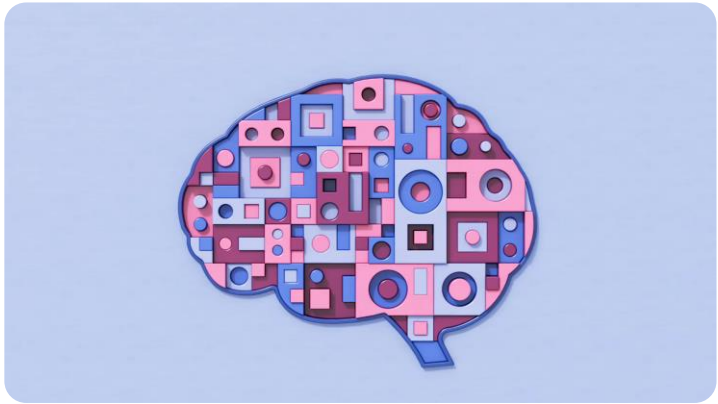
3.5 Demonstrate advocacy strategies.

3.6 Advance preparedness to protect population health during disasters and public health emergencies.

LEVERAGING GAMIFICATION

CONGRATULATIONS!

YOU NOW POSSESS INFORMATION REGARDING EIGHT CORE DRIVES OF GAMIFICATION OR HUMAN CENTERED DESIGN



4) Ownership & Possession

(Chou, 2019)

LEVERAGING GAMIFICATION

Eight Gamification Core Drives

(Chou, 2019)

LEVERAGING GAMIFICATION

ROUND ONE WON!

ENJOY YOUR ACCOMPLISHMENT & GET READY FOR WHAT COMES NEXT ON YOUR EPIC JOURNEY AS A DEI COMPETENCE CHAMPION

LEVERAGING GAMIFICATION

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