Reimagining the Status Quo: Nursing Curriculum Transformation with Virtual Reality

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ABSTRACT

Nightingale College's continuous focus on innovative, evidence-based design keeps the organization iterating on the curriculum with new higher education approaches and curriculum resources. One such initiative includes the College's multiyear virtual reality (VR) project focus to deliver a hands-on, simulated nurse training environment to enhance clinical reasoning and practical skill building. Learners use VR headsets to apply their skills and knowledge in the safety of a virtual environment that mimics real-life nursing situations. They are immersed in typical nursing scenarios, including diagnosing patients, instigating treatments, and interacting with the interdisciplinary team of virtual avatars. They may repeat experiences as often as they like, with the system offering multiple adapted outcomes based on their responses to fully interactive, simulated patients and their family members. They also receive personalized feedback, performance metrics, and a synchronous faculty facilitated debrief. Initial pilot data indicated excellent student feedback and improved outcomes in critical thinking and clinical reasoning, and data from the full program rollout of this resource continues to trend upward, as demonstrated in previous papers.

While the trendline for learner performance demonstrates positive outcome metrics, other factors of note previously presented remain for discussion. As most of the College learners use the VR headsets to complete their simulation assignments, some learners require the use of the screen-based version of the simulations to allow for academic accommodations and American Disabilities Act (ADA) compliance. Faculty training comfort with the tools to support learners in their skill development through high-fidelity simulation remains an ongoing area of focus. Additionally, work to disaggregate the data to ensure that while the aggregate of learners are succeeding with improved outcomes and increased clinical judgement and reasoning skills, that no subset of the population is inadvertently negatively impacted through the application of virtual reality in the curriculum. Efforts around these areas of focus areas are discussed as it relates to technology adoption in fulfillment of the institutional mission in overcoming educational equity gaps.

Within this paper, the authors share the multiphase rollout approach for the use of VR in nursing curriculum and discuss the challenges and interventions implemented between the initial pilot, full program rollout (previously presented) and the use of dual simulation modalities. The presenters share updated data around learners' improvement in clinical reasoning skills using VR as compared to the use of screen-based versions. Additionally, the authors discuss future augmentation of this initiative, including designing policies around VR/screen-based usage, specific curriculum changes needed to ensure learning equity and partnering in the creation of customized VR solutions based on identified curriculum gaps,

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BACKGROUND

Participating in a nationwide distance education program enables individuals throughout the United States to access high-quality nursing education. However, ensuring consistent quality and equal educational standards across all locations presents challenges, particularly regarding clinical placement and skills validation. Despite having an extensive network of partnerships across the country, Nightingale College does not own or manage any client-facing facilities. Consequently, the College relies on well-established partnerships to provide learners with tailored hands-on care experiences.

As lockdowns and isolation measures were implemented during the COVID-19 pandemic 2020, it became evident that the traditional approach to providing direct patient care experiences faced additional challenges. There was a pressing need to reassess how to develop curriculum experiences that were consistent, replicable, and aligned with the desired educational outcomes. Given the restricted access to traditional in-person facilities, it became crucial to fast-track the implementation of high-quality virtual simulation spaces to ensure learners could continue their educational journey and engage in meaningful interactions with clients.

A multi-phase approach was initiated to innovate the curriculum to include Virtual Reality (VR) and actively validate its impact on learner outcomes. The first phase involved integrating 2D computer-based simulation clients into a single curriculum course to provide support and maintain or enhance learning during the transition. Following an initial pilot, the curriculum expanded the integration to include using the 3D environment. This expansion ensured that the distribution, technical support, and faculty engagement were appropriately scaffolded to continue promoting academic success. The curriculum initiated the most recent phase over the past year and integrated virtual reality simulations into all clinical courses across the undergraduate nursing curriculum. Plans for the final phase of VR implementation include integration into non-clinical classes and soft skills training.

Overview of Curriculum

The Nursing Program uses a concept-based curriculum. Conceptual learning is an educational method that centers on big-picture ideas and learning how to organize and categorize information. Unlike more traditional learning models, which concentrate on the ability to recall specific facts, conceptual learning focuses on understanding broader principles or ideas (concepts) that can later be applied to various specific examples. The concept-based structure of the curricula facilitates the learner's journey through increasingly complex concepts, behaviors, and skills, providing opportunities for the learner to progress along the novice-to-expert continuum. Based on situated learning and cognition principles, all courses integrate concepts and information from all major areas of nursing practice within a contextual format of immediate and continuous application of prior knowledge and experiences. Within each concept-based curriculum plan, there is a defined list of concepts emphasized throughout the corresponding academic program. Developers consistently refer to critical concepts to select exemplars and sequencing of didactic instruction and experiential learning activities to support an integrated curriculum. The curricula are structured to ensure fundamental knowledge acquisition with a solid medical-surgical foundation occurring early in the pre-licensure programs. Specialty concepts are concentrated in the higher-level and master's degree courses and threaded throughout the programs.

The curriculum was sparked by the call for a radical transformation in nursing education presented in Educating Nurses (Benner et al., 2010), a Carnegie Foundation for the Advancement of Teaching study on preparation for the nursing profession, and other literature including the Institute of Medicine and Robert Wood Johnson Foundation report on The Future of Nursing. The curricula are grounded in current evidence and professional standards and reflect the programmatic philosophy, key concepts, and nursing practices.

In alignment with this mission and the goal of increasing geographic, demographic, and socioeconomic access to prelicensure nursing education, the College developed and implemented a learning delivery model accessible to learners in any setting. The implementation provided for the eventual substitution of high-fidelity virtual simulation for up to 50% of the direct, focused client care (clinical) experiential learning, consistent with program approval. In response to the coronavirus (COVID-19) pandemic, the College prepared and executed a response plan to avoid disruptions to the academic progress of its learners, ensure continued institutional effectiveness, and protect the well-being of learners, collaborators, patients, healthcare partners, and the communities it serves, which included implementation of virtual simulations earlier than anticipated. The vendor-created virtual activities are vetted nationally and integrated into other nursing programs nationwide. The integration of this new modality was designed to be consistent with nationally researched norms and practices that have proven effective in nursing programs nationally (Aebersold, 2018).

VRS Use in Nursing Higher Education

Virtual reality simulation (VRS) has emerged as an established educational method in nursing, helping learners tackle the challenges of transitioning to professional practice. With nursing schools facing increased competition for clinical placements and a heightened emphasis on patient safety, there is a growing need for alternative pathways that allow students to refine their essential clinical judgment skills. This necessity is underscored by the introduction of the NextGen (NGN) version of the National Council Licensure Examination (NCLEX-RN) in April 2023, which prioritizes clinical judgment in its question items (Dickison, 2019). Consequently, VRS presents a crucial opportunity to enhance exam readiness. The National League for Nursing (NLN) reports a rising interest in integrating VRS into nursing education programs, a trend projected to continue (NLN, 2021). This adoption is supported by the proliferation of nursing-specific virtual reality scenarios and the increasing familiarity of educators with this instructional tool. Through VRS, instructors can customize patient scenarios to provide repeated exposure to critical skills practice in a safe, controlled environment. Within these virtual settings, students can gather data, make informed decisions, and evaluate care outcomes. Multiple studies indicate that regular exposure to such simulations reduces anxiety among nursing students while bolstering their confidence, self-efficacy, and knowledge (Jallad, 2022; Pardue, 2022; Mabry, 2020). Further backing comes from a recent systematic review highlighting the cognitive and psychomotor skill advancements facilitated by immersive technologies like VRS (Choi, 2022).

VRS vs Traditional Education and Physical Simulation

Virtual reality simulation (VRS) and traditional simulation each offer distinct advantages but also share overlapping benefits. Due to their hands-on nature, physical task trainers and mannequins excel in teaching procedures like IV insertion and in-situ training. In contrast, VRS excels in providing flexible, repeatable, and standardized scenarios. Despite these differences, both methods can effectively address many learning objectives interchangeably. Brown (2021) compared VRS to traditional simulation in nursing emergency scenarios, finding VRS rated "good to excellent" for usability and providing a learning experience similar to face-to-face simulation.

Additionally, nurse practitioner students consistently reported superior experiences with VRS compared to in-person training. Harling (2018) demonstrated that VRS achieved comparable learning and performance outcomes to physical simulation at a significantly lower cost. PwC's 2020 study supported these findings, showing that VR learners were four times more focused than e-learners, learned four times faster than traditional learners, and had nearly four times the emotional engagement of classroom learners. Further validation comes from a randomized control trial by Padilha (2019), which found that VRS significantly enhanced nurses' knowledge compared to case-based learning and increased overall learning satisfaction.

Learner Benefits

The learner experience in virtual simulation consistently garners positive feedback, providing a memorable, inclusive, and engaging mode of learning (Saab et al., 2021, p. 1). Virtual simulation enables learners to effectively problem-solve and apply knowledge in a safe environment conducive to trial and error (Pal, 2022; Zackoff, 2020), mirroring the experience found in traditional simulation among nursing students (Brown, 2021).

Virtual simulation offers distinct advantages in repeatability and flexibility. Repeatability, a critical aspect of successful simulation, is often constrained by space, time, and faculty availability in traditional simulation centers

(Barry Issenberg, 2005; Butt, 2018). Virtual systems, requiring minimal faculty intervention, allow learners to engage in simulations conveniently, enhancing accessibility and flexibility (Pottle, 2019). Learners appreciate virtual platforms' expanded access and flexibility (Mendez, 2020).

Systematic reviews in nursing education highlight virtual simulation's effectiveness in achieving various learning outcomes. It facilitates the acquisition of knowledge and skills and boosts self-confidence, self-efficacy, and satisfaction while reducing anxiety (Jallad, 2021; Foronda, 2020). Moreover, research demonstrates that virtual simulation can deliver these learning outcomes equivalently or even more effectively than traditional and physical simulation methods (Brown et al., 2021; Haerling, 2018; Padilha et al., 2019).

Institutional Benefits

From an institutional perspective, virtual simulation offers rapid deployment to large numbers of learners remotely at a fraction of the cost of physical simulation (McIntosh, 2006; Zendejas, 2013; Pottle, 2019; Freeman, 2021). These scalability advantages and the virtual simulation's minimal space requirements were instrumental in its widespread adoption during the COVID-19 pandemic (Pal, 2022).

Virtual simulation often operates independently of faculty involvement, freeing up faculty time. While many setups advocate for a hybrid model with educator-led setup and debriefing to enhance learning experiences (Mendez, 2020; Brown, 2021), the simulations do not always require constant faculty oversight, optimizing operational efficiency. In instances where educator input is necessary, virtual platforms ensure objectivity and standardization of scenarios, maintaining consistent quality and removing bias from the learning and assessment processes. These systems also generate substantial performance data, which is crucial for maximizing utilization, fostering learner engagement, and identifying students who may benefit from additional training (Kim, 2021).

VRS vs Screen Based Learning

Current research in healthcare education strongly supports the effectiveness of Virtual Reality Simulation (VRS) compared to traditional screen-based learning. VRS is valued for its immersive qualities that enhance learning experiences and its ability to transfer knowledge and skills to real-world patient care scenarios effectively. Gutierrez's (2007) study in healthcare education demonstrated that VRS significantly surpasses screen-based learning in improving learning outcomes. Similarly, Bowman (2009) found that VRS notably enhances memory performance and enhances the application of knowledge in practical settings, in contrast to screen-based methods. Moreover, Makowski (2017) emphasized that the sense of presence offered by VRS significantly aids memorization compared to screen-based learning approaches. However, not all studies align with these findings. Azher (2023) discovered that VRS using headsets provided a comparable experience to screen-based simulation across performance scores, usability, cognitive resources, and emotional engagement. Further research is needed to fully explore the potential advantages and limitations of VRS relative to screen-based learning methodologies.

Efficacy of VRS

Several studies underscore the profound impact and effectiveness of Virtual Reality Simulation (VRS) in enhancing the learning experience. Brown (2023) highlighted the Oxford Medical Simulation (OMS) platform for its exceptional usability, with two-thirds of learners rating it highly on the System Usability Scale (SUS). The study also utilized the Simulation Effectiveness Tool-Modified (SET-M), revealing that 100% of learners rated the learning experience favorably, indicating substantial agreement across all SET-M components. The integration of OMS throughout the curriculum and facilitated debriefing was suggested to enhance patient care outcomes.

Mallick (2021) observed significant improvements in clinical confidence and performance among OMS learners, achieving outcomes aligned with Kirkpatrick level 3. Furthermore, 96% of participants recognized VRS scenarios as superior for knowledge retention compared to standard eLearning modules. Similarly, Seager's (2020) study demonstrated that learners using OMS experienced enhanced clinical confidence and performance, particularly in time management, prioritization, delegation, patient condition recognition, teamwork, and patient assessment skills.

Studies across various domains, including trauma decision-making (Harrington, 2017), resuscitation training (Creutzfeldt, 2016), and physician training in cardiac lead removal (Maytin, 2015), consistently validate VRS as a potent tool in healthcare education. Oxford Medical Simulation exemplifies this technology's transformative potential in improving learning outcomes and clinical skills development.

INTERVENTION RESULTS

As previously published (Olsen et al., 2022; Olsen et al., 2023), the intervention results have been the product of a multi-phase rollout beginning in the Spring of 2020 when traditionally performed on-ground simulations on-site with faculty were disrupted by the outbreak of COVID-19. Planned introductions of fully online simulated experiences, instead of on-ground face-to-face instructional environments, were accelerated to ensure learners could continue progressing in their academic and practical preparation. At the same time, the pandemic restricted traditional physical engagements. To ensure learners continued succeeding at normative levels, the College continued to assess learners utilizing the same nationally normed Health Education Systems Incorporated (HESI) exam, noting that the scores range between 0-1500, with 850-900 being the recommended performance range. Further, the fully online simulated experiences were rolled out in successive phases to ensure that individual populations could demonstrate success with the intervention at each level.

First, this section will quickly review the individual phase rollouts with associated HESI performance data from the Spring of 2020, prior to intervention, to the Spring 2024 semester, indicating when the intervention was affected and the current trend data for ongoing sustainability. Second, we will review how the intervention currently performs between the VR goggles modality and the 2D web-based screen modality to understand how the simulated environments compare to the physical traditional models previously employed and how, even within the simulated environment, the introduction of 3D Google utilizing the same tools supported transference and testing success.

Phase I Rollout

In the summer of 2020, the transition to computer-based high-fidelity simulation began in the BSN 266 course, which utilizes the MedSurg HESI exam. As evidenced in Table 1, total mean results increased by 74 points to within 19 points of the recommended range in that semester and rose to remain at or above the target performance range. Further within Table 1, in the Fall of 2021, the curriculum introduced VR goggle headsets utilizing the same VR simulations already integrated within the 2D web-based screen-mediated environment, leading to a further 48-point mean gain on the HESI exam within the optimal performance range. A year later and aligned with the Phase II results explored in Tables 2 and 3, the BSN 266 course transitioned fully to 3D VR goggle headsets as the primary delivery modality with the 2D screen-mediated environment reserved for ADA accommodations and health concerns that arose. The results of these interventions shown in Table 1 demonstrate that the introduction of high-fidelity simulation in this course increases learner performance, and at each new transition in modality to increasing levels of technological sophistication, learners have seen steady and incremental gains in outcome performance.

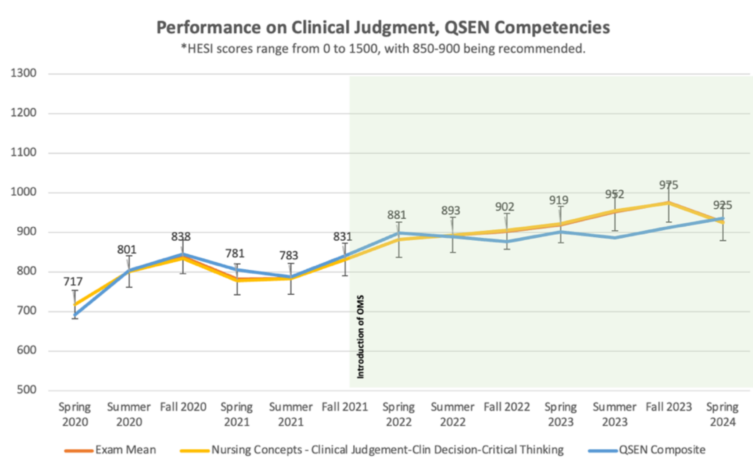

Figure 1: HESI exam results in BSN 266 broken by exam mean and QSEN composite scores

Phase II Rollout

Building on the success of the phase I rollout in BSN 266, in the Fall semester of 2022, VR simulations utilizing the VR goggle headsets as the primary modality were rolled out into the BSN 346 (Obstetrics HESI) and BSN 366 (EXIT HESI) courses. Unlike the first phase, this population had already been exposed to 2D and 3D simulation environments during the BSN 266 course, reducing the learning curve of needing to learn how to use the tool in addition to the content in their courses. While phase I simulations replaced all Direct Focused Care (DFC) experiential learners due to the necessities of COVID-19 lockdowns that restricted access to physical, experiential learners, phase II simulations served as a crucial part of experiential learning and not a replacement in these courses. The Obstetrics and Exit HESI results delivered in BSN 246 and BSN 366, respectively, are presented below in Figures 2 and 3.

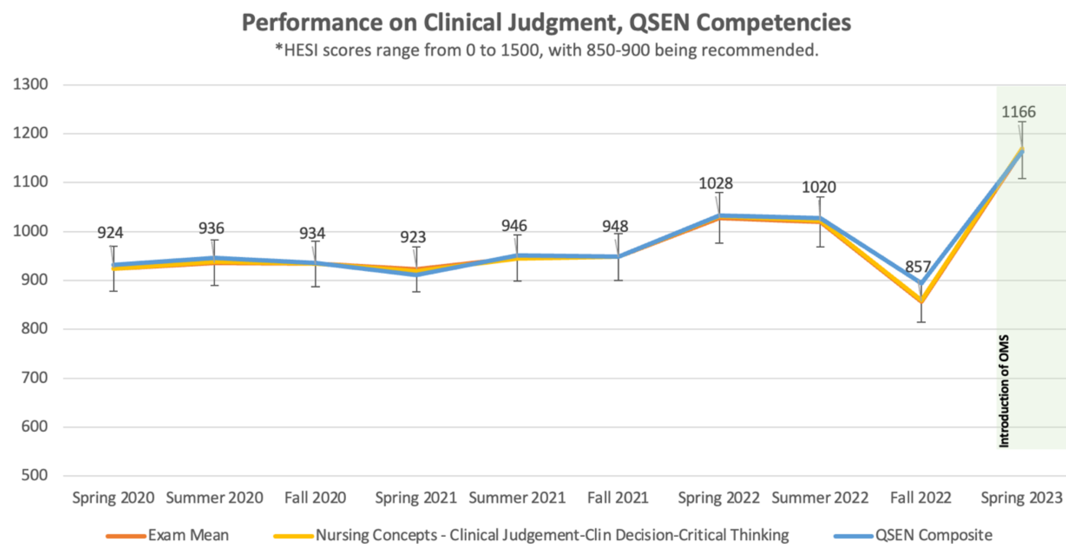

Figure 2: HESI data for BSN 346 broken down by exam mean and QSEN Composite scores

Similar to the Fundamentals HESI in Figure 1, Figure 2 below demonstrates a similar initial sharp dip in performance outcomes followed by a sharp increase the following semester. Factors that influenced this dip and rise are detailed in a prior publication (Olsen et al., 2023). Notably, no additional data appears in the table after the Spring 2023 semester for this intervention, as the College elected to move to a different assessment model in this course that is aligned with programmatic outcome needs and ended the HESI data collection after that semester.

Figure 3 below shows a more volatile series of results with more slow tending data upwards but aligning a more chaotic cycle for valleys and inclines. Overall, in the 3.5 years of tracking data, the initial low has risen to a 171 increase from the first to last measure currently averaging since the introduction of the simulation resources in the low-mid 900s, above the nationally normed predictor scores for NCLEX-RN first-time pass rate at 900 for high probability score of passing on a first attempt.

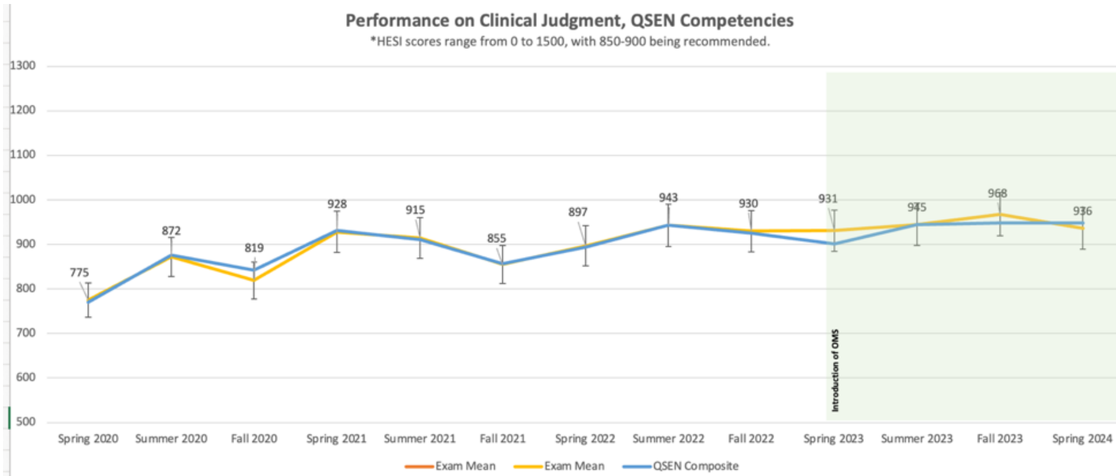

Figure 3: HESI scores for BSN 366 broken down by exam mean and QSEN Composite scores BSN 366 EXIT HESI

Phase III Rollout

Given concerns with the simulation tool app rollout with the app store in the VR headsets, plans for a full curricular rollout of the simulation were postponed, and the BSN 205 course focused on early nursing Skills Assessment was moved into the VR space. In the Spring of 2023, VR was introduced into BSN 205. Notably, in Figure 4 below, there appears to be more seasonality in the results than later in the program, partly related to learners acclimating to the yearlong academic calendar where Summers appear to be the lowest performing semesters, with Fall improving and Springs traditionally performing best of the three. This level of seasonality in results does not appear in the other courses or tables. From Spring 2020 to Spring 2024, through the tables, there appears to be a slight negative trend line that is neither affiliated with the introduction of the simulation tools nor other traditional interventions within the college learner experience. Notable, this is only a 7-point decline from the first measurement to the last, but this negative corollary is subject to further investigation.

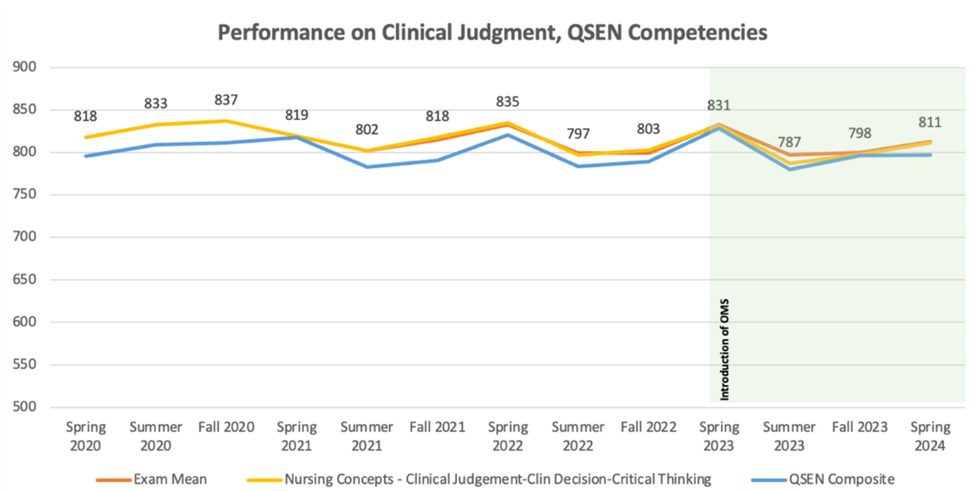

Figure 4: HESI results in BSN 205, broken down by exam mean and QSEN Composite scores

Modality Comparison

The figures and phases above have highlighted the performance learning outcomes from the traditional face-to-face models to high-fidelity simulation models and the trending performance outcomes within those intervention spaces. It does not break down the two modalities for delivery of those simulations in any intentional or disaggregated way, which we will highlight in figures 5-11 below. As indicated above with the phase II rollout when VR goggle headsets were established as the primary modality for delivery of the high-fidelity simulations, and noting that the 2D screen-based versions remained in utilization for health or ADA accommodation uses, a comparison of the two spaces to ensure no significant deviation in performance outcomes among disaggregated populations is warranted. The data tables to follow are analysis outcomes from the Spring 2024 semester.

Figure 5 below compares the time spent in any simulation between the group utilizing 3D goggle headsets (left) and those in the 2D screen-based simulation environment (right). Those performing in the 3D Goggle environment demonstrated a 5.59% higher average score on simulation assignments than those working in the 2D environment; however, there is a positive correlation between scores and minutes spent in simulation in both the 3D and 2D groups.

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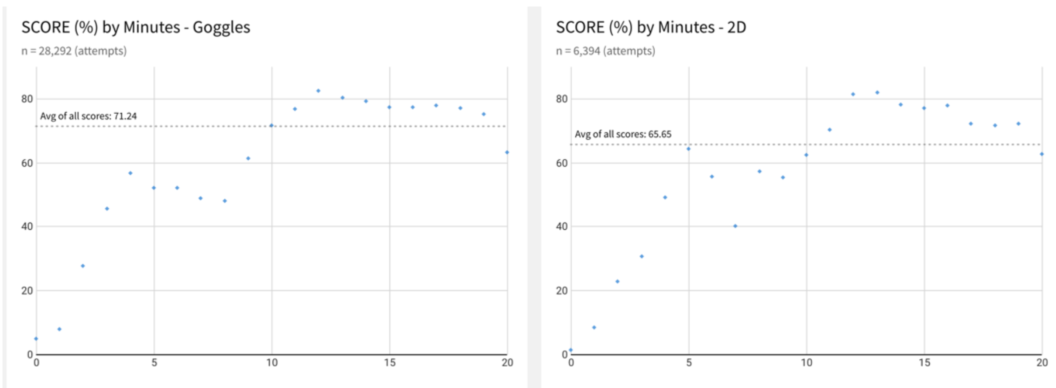

Figure 5: Score by minutes comparison between 3D and 2D learner populations

Breaking down the average score and average minutes spent on a simulation against the attempt in Figure 6 below, the average score decreases as the attempts increase, especially after attempt 4. This may correlate with the idea that the time spent on the later attempts is typically lower than that spent on earlier attempts. Further, there is an indication that the 3D goggle group scores higher with fewer attempts at a singular simulation. While both groups can score within similar levels within a margin of error, the 3D goggles groups appear to score marginally higher in fewer attempts and less time in the simulation. Note that on the table, the no group is the group in a 2D space, and yes, it is in a 3D space, meaning they did use a Quest 2 pin to access the simulation with the Goggles.

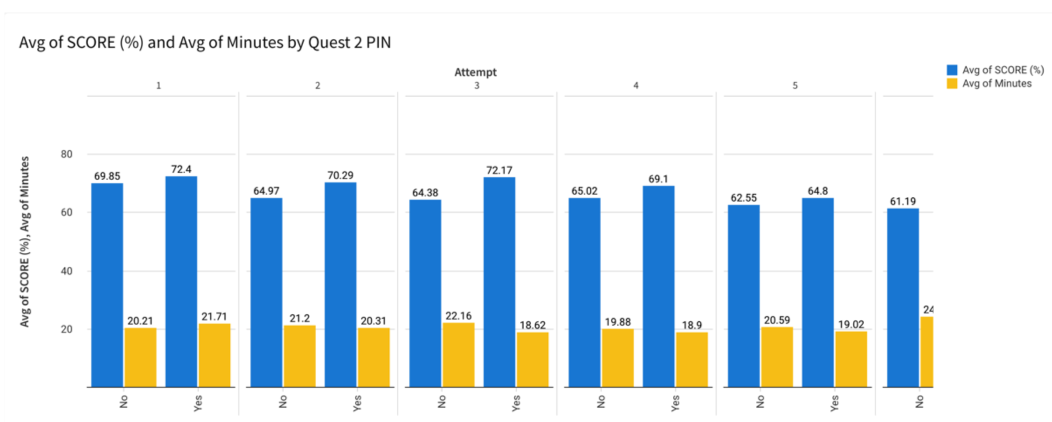

Figure 6: Average score and average minutes by attempt between 3D and 2D groups

Disaggregating this data further to identify if any individual learner populations may be individually or independently impacted differently than the collective trend data would suggest, this population is broken down by score and disaggregated groupings by race, gender, previous preparation (foundations), and socioeconomic groups in figures 7-11 respectively below.

Figure 7 below breaks down performance scores by Race, following current U.S. Government classifications, and highlights between those using the 3D goggle headsets (yes) and those that are in the 2D screen-mediated environment (no). While the most extensive spread for variation between the 3D and 2D spaces is 15.09 points for the American Indian/Alaska Native population, all other groups with a positive, more robust 3D performance between the 2D and 3D environments, all other groups were within a 7-point margin of error max. Notably, Native Hawaiian/ Other Pacific Islander populations saw the only negative 3D to 2D environment result, with 2D spaces outperforming 3D by 8.98 points. This population-based inverse result bears further study.

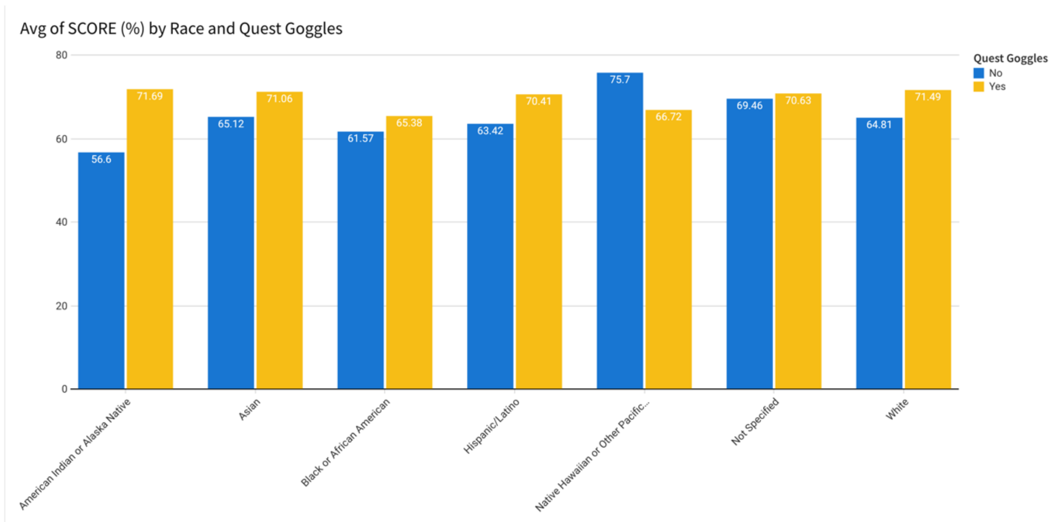

Figure 7: Average score by Race between 3D (Yes) and 2D (No) environments.

Exploring that same data broken down between genders in Figure 8 below demonstrated a minor variation between the genders. Notably, the college population here displays only the gender binary of males and females, as those self-identified in other classifications were below the 1% cutoff for reporting here. In this breakdown, both men and women trended more positively in the 3D environment, with women showing a 5.02-point delta and males showing a 3.83-point delta.

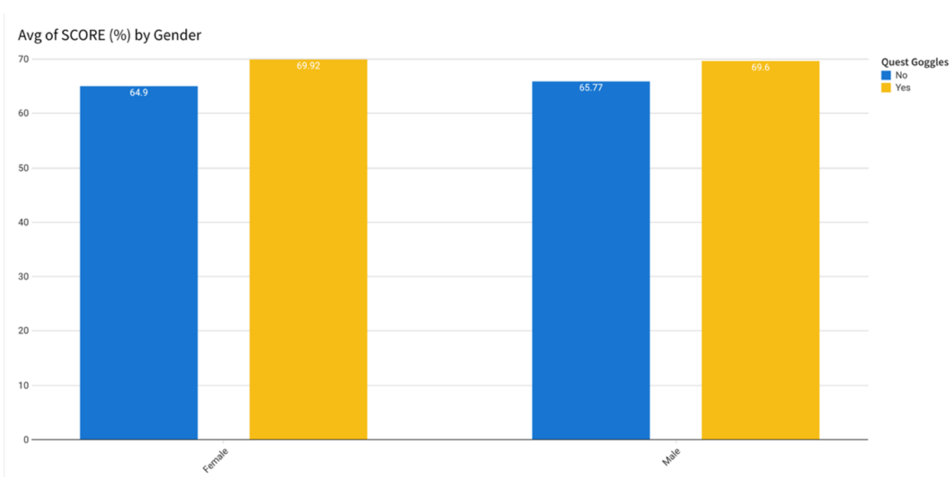

Figure 8: Average score by Gender between 2D and 3D environments.

Within the college admissions process, learners scoring below a specific cutoff on the entrance exam are required to take a skill-building course as part of the pre-enrollment process for admissions. This skill-building program is broken down into math and reading courses. For this analysis, previous engagement in the Foundations program could indicate previous academic preparation gaps, extended time away that required skill refreshing, or extensive test anxiety that may have impacted test-taking abilities and alternately demonstrated required skills by successful course performance. Internal data has suggested that this population requiring foundations for any reason is most at risk of poor academic performance and the potential to withdraw prior to completion. Therefore, it is monitored for ongoing and increased learner support. As highlighted in Figure 9 below, all learners performed more in the 3D than in the two environments, with those having not required the Foundation's program showing a delta of 4.76 between the two environments and those having taken the Foundation's program outperforming their peers on the 3D by .94 points and showing a slightly broader delta of 5.55.

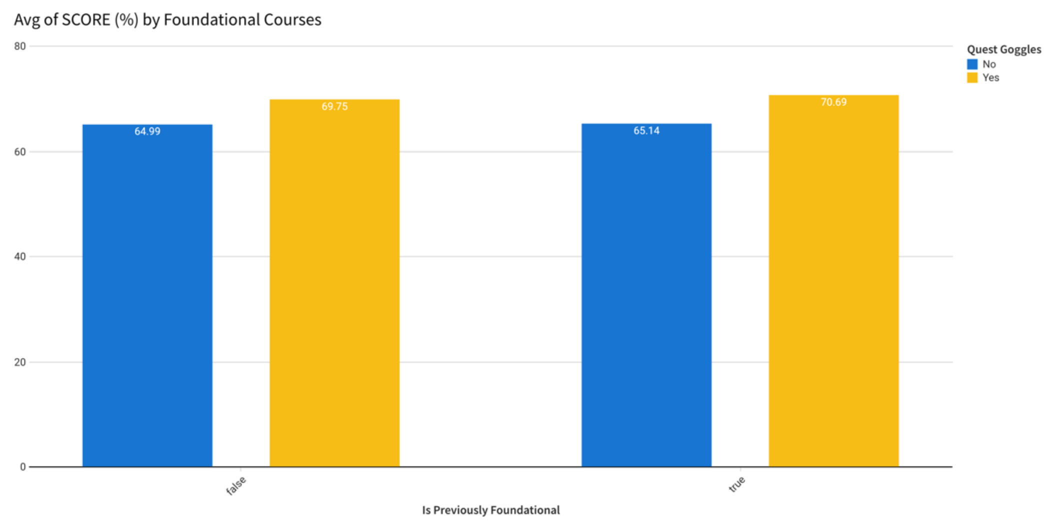

Figure 9: Average score by previous Foundational Course participation between 2D and 3D environments.

For this data, socioeconomics was broken into groupings defined by Pew Research (2022), as indicated on financial aid qualifying documentation. Income brackets are defined as follows: a lower income threshold of $52,000 for a household size of 3, the middle-income threshold of $90,000, the upper-middle-income of $123,000 using the midpoint between middle and upper-income thresholds, with an upper income of $156,000 or greater. All groups performed higher in 3D goggle headset environments, with the most significant delta spread in the lower-income group, at 6.44 points, and the lowest delta spread in the middle-income group, at 3.02. Upper and Upper middle have a range delta between 3.28 and 4.42, respectively.

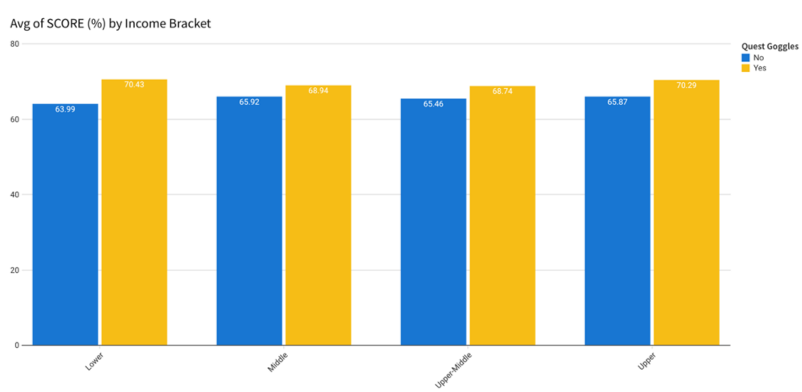

Figure 10: average score by income brackets between 2D and 3D environments

Overall, the 3D environment showed a more robust performance average in all categories and between all groups outside of Native Hawaiian/ Other Polynesian populations. The exact causes for worse performance in this population subset are unknown at this time. Further, the performance results are achieved in statistically less time and fewer attempts within the 3D environment compared to the 2D screen-mediated environment. The exact causes of this potential disparity are also unknown at this time.

Challenges

The exact reasons for the slight statistical performance success delta between the 2D and 3D environments remain a subject of investigation to ensure that those receiving accommodations for ADA or other health concerns are not intentionally or unintentionally disadvantaged by receiving accommodations. Investigation of additional interventions for those with provided accommodations to ameliorate potential disparate performance gaps between groupings remains to ensure design equity. Further, deeper analysis within the subpopulation of Native Hawaiian and other Polynesian learners to determine the exact cause of why they may be performing in divergent ways between the 2D and 3D spaces from the remainder of the College population remains an open inquiry. While reasonably normative performance is being reached between this population and the remainder of the College peers, determining how to ameliorate this performance variance is essential to ensuring educational design opportunity and access equity for all learners.

Next Steps

As VR technology has seen statistically significant success with the High-Fidelity simulation rollouts in 2D and 3D modalities since the initiation of this curricular integration in 2021, an ongoing review of current and future causes of disparity in the data between performance and subpopulations remains ongoing. Further, the types, styles, and development of VR scenarios need to be validated each time a new simulation is introduced. Further assessment into the transition of knowledge from simulated reality to physical practice in a clinical space remains a rich vein for research.

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