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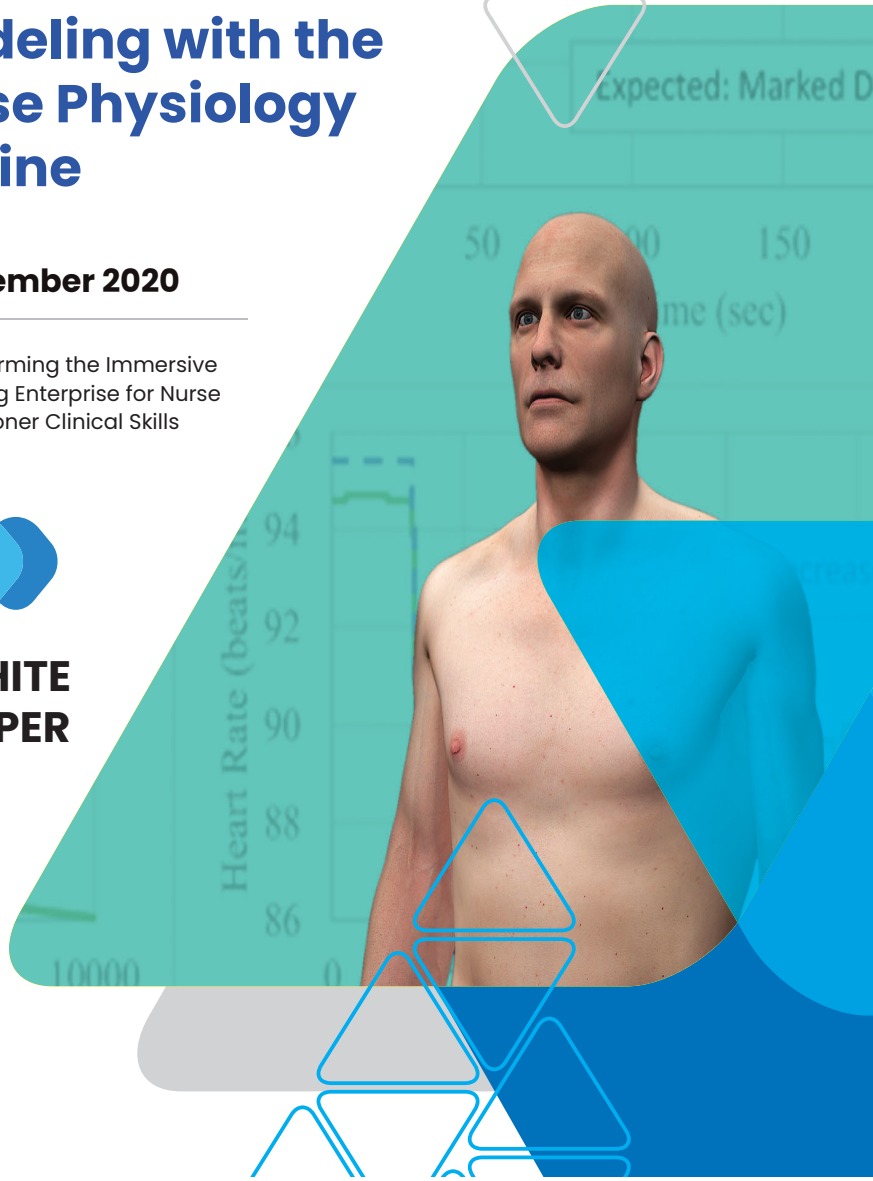
Virtual Patient Modeling with the Pulse Physiology Engine

September 2020

Transforming the Immersive Learning Enterprise for Nurse Practitioner Clinical Skills

WHITE PAPER



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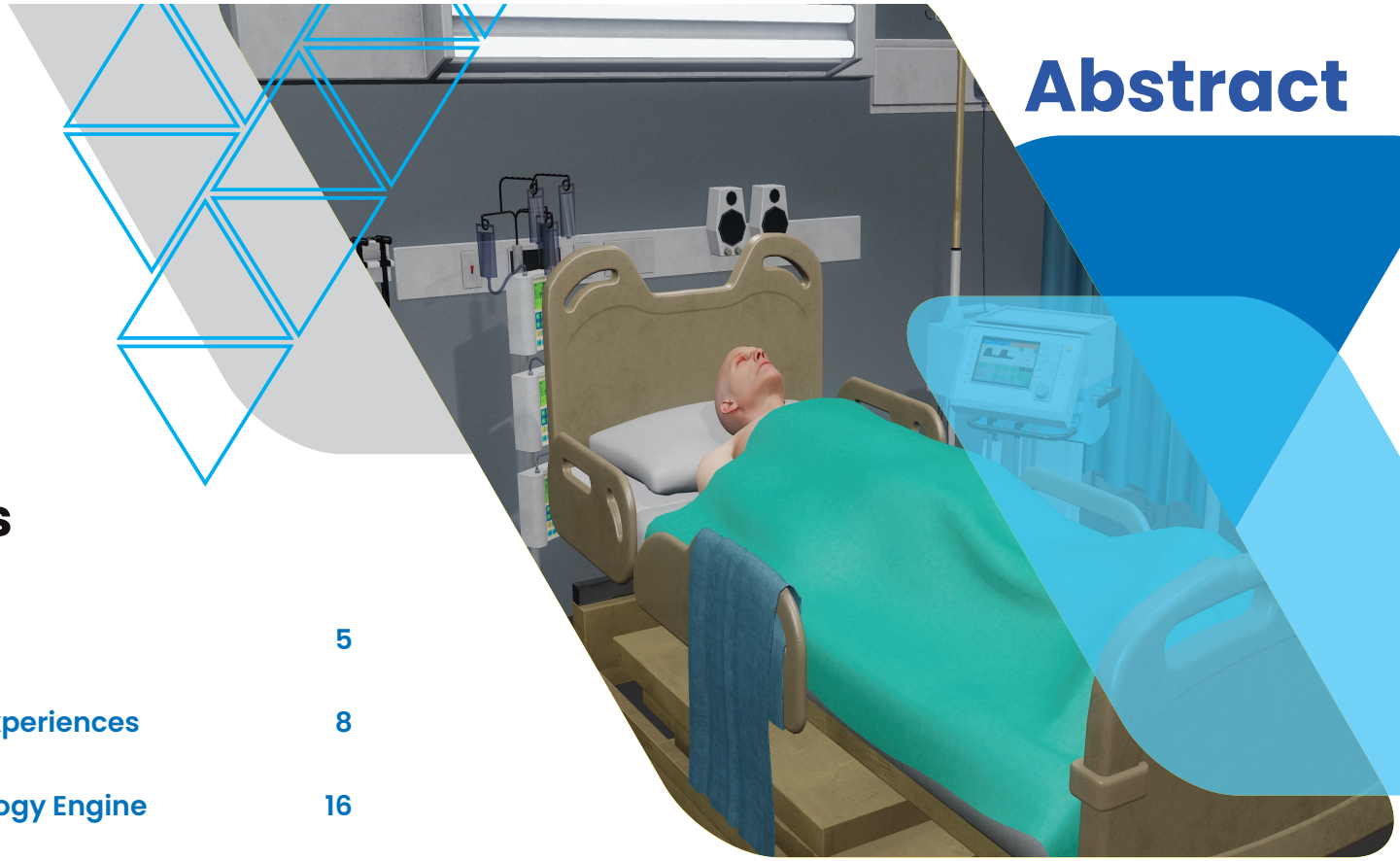


Abstract

Persistence

Skills are acquired more rapidly, with greater accuracy, and are retained longer through immersive learning (VR). The Physiology engine affords leveraging empathy, where the patient story is brought to life in the immersive learning experience with real-world case data. This empathetic connection has a profound impact upon the persistence of learned skills.

Diversity

Due to limitations of existing products in nursing education, the opportunity to customize patients and scenarios has been limited. The Pulse Physiology Engine empowers immersive learning with patient types and case scenarios that are customizable by the faculty to better prepare students to care for and manage patients from different racial and ethnic backgrounds.

Overview

Virtual Patient Modeling with the Pulse Physiology Engine is Transforming the Immersive Learning Enterprise for Nurse Practitioner Clinical Skills Education.

About Immersive Learning

Simulations have been a mainstay for decades in clinical training for nursing. Recently, Immersive Learning with affordable consumer Virtual Reality (VR) headsets has emerged as a paradigm shift in simulations for healthcare education. Educational institutions are aware of the innovation opportunities and are committing resources and creating new curricula and programs using Immersive Learning (VR) solutions.

Purdue University Global is a pioneer in delivering immersive learning. Faculty and students in the School of Nursing collaborate with industry leaders like inciteVR to move the discipline forward.

The Clinic Immersives Nurse Practitioner Skills Lab Enterprise in use by the School of Nursing at Purdue University Global was developed by inciteVR for Nurse Practitioner (NP) learners to practice and demonstrate clinical skills competencies "anytime, anywhere". Learners use their own Oculus Quest mobile VR to access the Cloud-based learning experiences. No travel is required, availability of practice is nearly unlimited, analytics of learning outcomes provide insight for every aspect of clinical skills labs, learner performance, and learner and class skills gaps. Additionally, research has shown that learners acquire skills more rapidly, with greater accuracy, and retain learning longer through immersive learning experiences.

Immersive learning with VR is more than just a new technology. It is a unique type of learning experience. Achieving the maximum learning benefit from immersive learning experiences requires a fundamental shift in approach - moving from the legacy focus of designing and implementing learning products for institutional needs, practices, and structures to a focus where the learner's experience is truly at the core and the learner's personalized instructional needs are the overarching guiding framework.

The technologies, tools, and processes required to develop immersive simulations are available, affordable, and can go to scale. It is possible to design, produce, deliver, and support a personalized immersive learning experience for nursing clinical training that leverages presence, embodiment, empathy, and presents a hereto unseen level of engagement.

About This Paper

This paper investigates a subset of the myriad tools and processes used in developing immersive learning - which incorporates the use of an embedded physiology engine framework to both leverage empathy and broaden the diversity of clinical practice experiences.

Specifically, this paper presents a case study of how inciteVR incorporates the Pulse Physiology Engine (https://pulse.kitware.com/) developed by Kitware, Inc. (https://www.kitware.com/) in the Clinic Immersives NP Skills Labs Enterprise and the impact this has had upon the NP Learners at the School of Nursing at Purdue Global University.

Achieving diversity of clinical experiences

Achieving accuracy and diversity of clinical experiences in immersive learning for Nurse Practitioners is a primary objective of the Clinic Immersives NP Skills Labs. Achieving this objective through patient modeling with real-world case data is empowered by the incorporation of the Pulse Physiology Engine.

Several racial and ethnic disparities in public health have been of growing concern and have been brought to the forefront amid the SARS-CoV-2 pandemic. Immersive learning (VR) can provide clinical scenarios with a range of patients from different racial and ethnic backgrounds to better prepare students to care for and manage patients within those populations addressing an urgent health care need.

Benefits of clinical training through immersive learning

Nursing schools across the nation have been challenged in offering immersive clinical experiences to students in the midst of a global pandemic. In person clinical experiences have been limited due to the SARS-CoV-2 virus and have posed unprecedented circumstances in providing students with learning experiences in the clinical setting and in a face to face format. Virtual reality simulation and immersive learning technology have been implemented at a variety of levels to provide immersion experiences to students in many disciplines inclusive of nursing, aviation, military training, dental school training and medical procedures. The pandemic has catulpted nursing educators to push the envelope to ensure safe, quality clinical experiences that align with the educational outcomes identified for their specific programs from state boards of nursing, licensing and credentialing bodies to meet the current challenges in nursing education.

Historically, VR has been used in some areas of nursing education to foster knowledge acquisition and skills retention. Immersive experiences (VR) can allow for students to experience real life scenarios

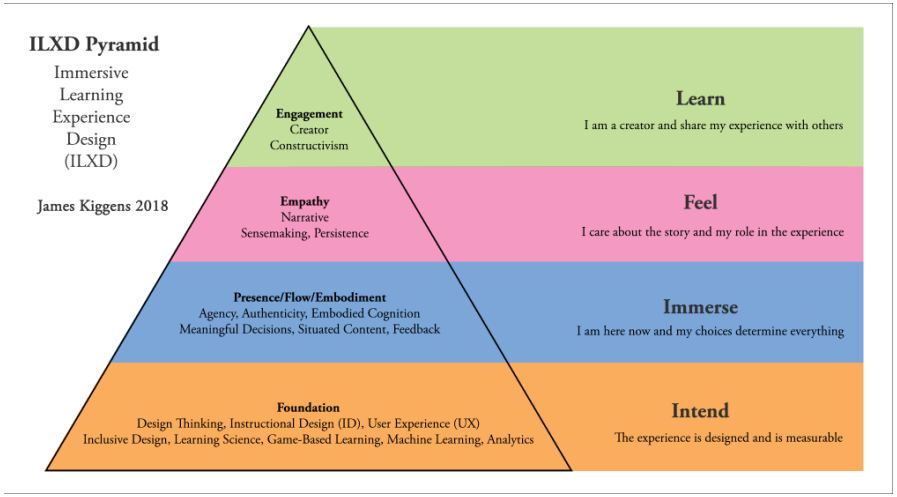
relevant to their program from the comfort of their own home with unlimited access, and any-where any-time opportunities for learning. This specific VR experience has taken the place of the “see-one, teach-one, do one” model that would be provided in the face to face skills lab course. Differing modes within the lab experience allows for the student to practice the skill in a guided, expert and exam mode. Although limited, some preliminary studies have indicated that learning outcomes using virtual reality simulation may have learning outcomes that are equal to or better than traditional methods.

The use of simulation can enhance a students clinical experience by exercising motor skills, decision making skills, and communication skills in a variety of clinical settings and scenarios. Virtual reality and immersive learning technology has the potential to facilitate and enhance the students ability to improve knowledge retention, skills acquisition, and self-efficacy in learning incorporating the use of many pedagogical teaching approaches.

In addition, several racial and ethnic disparities in public health have been of growing concern and have been brought to the forefront amid the SARS-CoV-2 pandemic. VR has the aptitude to create and build patients from different racial and ethnic backgrounds to better prepare students to care for and manage patients within those populations addressing an urgent health care need.

As the U.S. economy aims to recover from the pandemic, nursing institutions have the need to evaluate and address the need and cost implications for in person SIM centers to maintain viability in the market. Using unique strategies, including the use of VR simulation experiences may elevate student experiences independent of geography or location and provide an immersive, dynamic and interactive experience for learners. Technology‐enhanced simulation for Emergency medicine (EM) learners is associated with moderate or large favorable effects in comparison with no intervention and generally small and

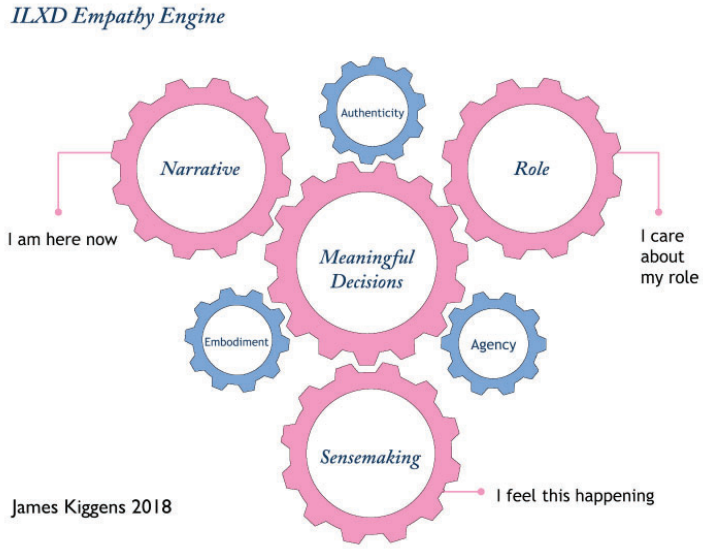
nonsignificant benefits in comparison with other instruction. Technology itself is not the educational solution, but the use of technology has a supportive role that in a blended approach of learning can perform a function that enables flexibility and self-paced learning. The use of VR platforms may have a significant impact on educational costs, safety and objective performance evaluation. The use of simulation to provide essential clinical experiences is a "core educational strategy because it is measurable, focused, reproducible, mass producible and importantly, memorable.



Increasing breadth of experience through real-world case data

Intelligent immersive learning is a paradigm shift that is already underway in healthcare education. The technologies, tools, and processes are available, affordable, and can go to scale. It is possible to design, produce, and deliver a personalized learning experience with immersion, empathy, and a hereto unseen level of engagement. The ILXD model is a shift in focus from producing learning products to producing learning experiences. The elements of the ILXD model are drawn from a broad array of pedagogy and educational technology topics, including; cognition and learning sciences, game-based learning, design thinking, virtual reality (VR), and artificial intelligence (AI).

A core design objective in the ILXD methodology is leveraging empathy to improve persistence of learning. We are built to understand the emotions and actions of others. Empathy is a major force in human behavior, so attaching empathy to learning in order to change behavior (apply learning) is essential. There is hard evidence that empathy and academic performance are correlated. Attaching feeling to learning compels the learner care about the story and their role in the experience. Toward this end, we attach all learning to "self" by providing agency to the learner. We enable the learner to construct the learning for



Achieving the maximum benefit from immersive learning experiences requires a fundamental shift in approach - where the learner's experience is truly at the core and the learner's personalized instructional needs are the guiding framework.

themselves and to use what they know to relate to the world around themselves.

In ILXD, the Empathy Engine provides a replicable, systemic approach to building empathy include using narrative and sensemaking. An outcome of a well-designed, empathetic immersive learning experience is persistence.

Sensemaking is the articulation of the unknown. It enables a learner to make sense of the world so they know how to act in it. In immersive learning, when the learner asks, "where am I and what is happening?", they are sensemaking. It's a method of making sense of an ambiguous situation and creating situational awareness in complex or uncertain situations in order to make decisions.

This natural strategy requires the learner to create a "map" of a changing world, then test the map through data collection, action, and conversation in order to refine the map. The continuous effort to develop a plausible understanding of the world, testing it, and refining their own understanding helps motivate the learner to make connections in order to act effectively.

In order to get the most out of this strategy, immersive learning must be designed with stimuli placed into a framework within the learner's zone of proximal development so learners can understand, explain, and then apply, analyze, synthesize, and evaluate information. These adaptive challenges require responses

Immersive Phenomena

"I care about the story and my role in the experience."

"I am here now and my choices determine everything."

"If you are there and what appears to be happening is really what is happening, then this is happening to you."

just outside of a learner's existing skill set, taking advantage of the gap between what they want to achieve and what they can achieve. By acting in VR, they are able to understand their new reality and assign meaning to new concepts.

Through sensemaking, learners can use their reasoning, intuition, logic, and emotional intelligence to navigate successfully through 'case stories' to move from "what is" to "what it can be" based on the learner's decisions. We can create meaningful, interactive, and challenging worlds involving the learner as the conductor of their own development.

Narrative, role, decision-making (agency), and sense-making are all facilitated by using the Pulse Physiology Engine to 'bring the patient to life' with real-world case data. The result is a learner that cares about the 'story' of the simulation and their role in how it unfolds - which is entirely under their direct control. This empathetic connection to the learning experience is deep and long lasting - which contributes greatly to the persistence of learned skills.

Purdue University global has partnered with Incite VR to build an immersive acute care skills lab for students in the Adult Gerontology acute care Nurse practitioner (AGACNP) program to provide students with critical experiences in the acute care setting. The Adult-Gerontology Acute Care Nurse Practitioner program currently requires students to travel to a Purdue Global location to complete an in person skills intensive.

Due to COVID-19 safety precautions and travel restrictions, the SON had to develop a skills lab offering to the AGACNP students. The students were tasked with completing multiple immersive labs including: endotracheal intubation, paracentesis, thoracentesis, suturing and central line placements. The immersive skills lab experience allows nurse practitioner (NP) students to develop clinical lab skills using their own affordable mobile VR with unlimited access, anywhere-anytime, using hand tracking inputs to practice in either guided or expert modes. NP learners and faculty access the Clinic Immersives NP Skills Labs through a Cloud-based enterprise that provides application control, headset control, learner progress monitoring, and rich analytics reporting. Casso et al., has noted that a high-fidelity simulator with training on VR bronchoscopy and fiberoptics simulators has shown to significantly improve time to intubation versus no training (Casso, shoettker, Savaoldelli, Azzola, & Cassina, 2018) VR also allows for skills to be repeated through deliberate practice, helping instructors measure competence and validate outcomes. One study indicates that "medical students demonstrate a significantly higher knowledge gain when using an immersive environment rather than screen based learning."

The AGACNP skills lab has been useful in teaching the student different procedural steps in which they may not have the opportunity to practice in the in-patient setting. This platform can identify student mis-steps or mistakes in the process in a safe virtual laboratory environment. Of the 53 students that participated in our inaugural acute care skills lab, all students were successful in connecting and accessing their skills lab via their Oculus Quest headset. In this experience, the completion rate of the lab was an astronomical 96.7%.

When compared with their previous immersive products in the classroom, inciteVR observed that the overall student engagement, success and perseverance to connect to the acute care lab was remarkable.

In reviewing literature, it is noted that there is a potential for a 200-2000% increase in skills acquisition with the implementation of VR.

Importance of customizing clinical clinical experiences

Due to limitations of existing products in nursing education, the opportunity to customize patients and scenarios has been limited. VR has the opportunity to modify the patient scenario to best fit the current needs of healthcare in the U.S.

As mentioned above, several racial and ethnic disparities in public health have been of growing concern and VR allows for opportunities that address these urgent needs and enhance a students' exposure to patients from different ethnic and cultural backgrounds. Simulation experiences offer an authentic means of developing clinical competence and demonstrate their mastery of knowledge, skills and abilities in the performance of specific job ranks as in important means of addressing the gap between NP education and practice.

The use of virtual reality simulation experiences have the depth to mirror real world experiences in nursing education and offer learning experiences with diversified environments and a vast range of patient

Immersive Enterprise

Exposure to a nearly unlimited range of patient types and cases, targeting skills gaps, and customized to meet job rank, regional, and late-breaking healthcare needs.

types and case scenarios. In a clinical environment, students are not guaranteed exposure to procedures. Oftentimes, Nurse Practitioner students are completing clinical experiences at acute care facilities and have to compete with other students, residents and fellows for hands-on clinical skills experiences. Due to this, exposure and opportunity to complete acute care skills may be limited.

Through delivery in an immersive enterprise, the students have unlimited exposure and attempts to practice and navigate the desired skills. As mentioned above, the VR cases allow for flexibility in the patient case, level of critical illness and exposure. The VR patient scenarios and cases are built with data driven physiology information to embody an true to life representation within the lab and provide for a more memorable experience.

Since 2016, the team at inciteVR has been interviewing nursing educators at conferences and events regarding the features that they most need in immersive learning for clinical training - and the ability for faculty to customize scenarios is consistently cited as a very high priority. They report that early products to reach the market tend to be 'one size fits none' VR applications with a very limited number of scenarios and no ability for the institution and faculty to customize the product.

The capacity of immersive client-server enterprise solutions can be immense, but are often difficult and expensive to realize in learning applications.

Integrating an off-the-shelf physiology engine product in the immersive learning solution maximizes the efficiency and effectiveness of the immersive enterprise - providing affordable Cloud-based access to faculty and staff to add and revise patient types, cases, and settings using the Web Dashboard's menu system and inputs to select parameters to create or revise custom scenarios. This data from the enterprise server is supplied to the client application in VR - where the physiology engine brings the scenario to life informing behaviors and displays that the learner encounters as if they were in the real-world.

Implementing the Pulse Physiology Engine

Fidelity is one of the top focus points when creating an immersive learning experience, and it weighs in almost all decisions. But it is important to note that high fidelity does not always mean good visual quality. If that was the case then Mobile VR would always be at a disadvantage when compared to PC VR. As we were developing this product we studied and implemented several features which enhanced the overall

Four years of learner and faculty feedback has shown us that fidelity for immersive learning is more than just visual quality. The quality of interactions and the accuracy of behavior and data representations are equally important.

Achieving high fidelity with a Mobile VR enterprise

experience, almost mitigating the difference between having the experience being rendered in a mobile device versus a dedicated and high end GPU that PC VR requires. Next we will describe some of these features and the impact which they had on our immersive learning experience.

Everyone in this industry knows the difficulty in explaining a new VR user how to interact with their experience. We try to make every interaction as simple as possible, with big letters explaining what they have to do, but they still manage to push the wrong button

and close the application. Both the user and the developer get frustrated, the former due to their inability to figure out what they have to do, and the latter because even though they spent hours thinking of all the imaginable things the end user could do, the user still managed to come up with a new one.

With mobile VR we have a significant advantage from the get go when compared with PCVR: there's no cables. Plenty of experiences ask users to constantly be moving and looking all around, and for those the

Reduce Friction

cables are their worst enemy. When users get tangled up on the headset cord or try to reach a place but the cord is already at its limit, they get immediately transported back to reality which completely breaks their immersion.

Although physical limitations are one of the most common reasons for friction, a poor user experience can put to waste all the positive aspects from mobile VR. Thus, it is of extreme importance to be thinking how the end user will use our app under all circumstances.

As we were developing our experience we came across a challenge in one of our first test sessions. Based upon user feedback from past products, we made sure that all interactable objects were within hand reach and in the user's field of view. Soon after the users started testing our experience, we began hearing that they had difficulties interacting with the patient and the tools, they were too tall to reach them. Even though we made sure to position everything correctly, we didn't consider an external aspect on the user experience equation: their VR setup.

There were multiple solutions for this problem, we could allow the users to interact with objects from farther away, we could give them an option to lift the bed and the tool's cart to better match their heights. Still, we weren't pleased with these solutions, for example on the latter we would be asking the user to adjust the height of multiple objects every time they joined a lab, we can't have something like that when one of our goals is to have a frictionless experience.

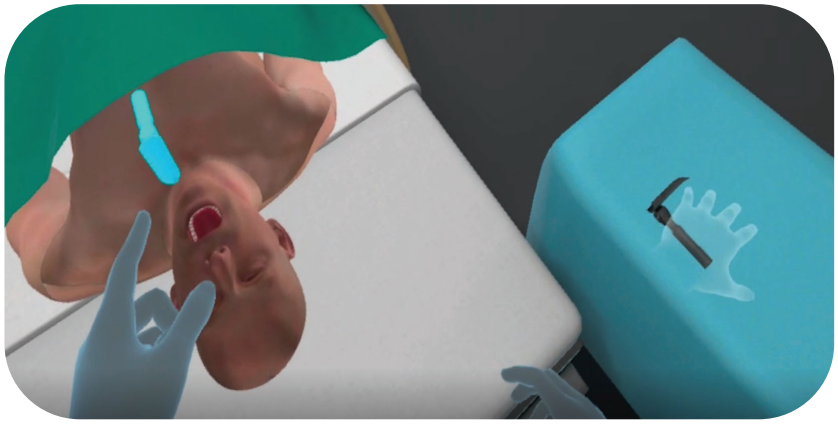
The ideal height was different in all of our labs, some of them we were only interacting with an arm and we didn't need to be at normal height, being shorter in those labs made a better experience since we wouldn't be asking the user to be leaning for the whole session. We needed a one time and easy setup to get the perfect height for every user. The solution was to make a calibration system when the user first launched

our app, we gave them an option to adjust their height so they could easily interact with some tools, then we would save and use it for all of our labs. Since we knew what the ideal height was for each lab, we could make use of the calibration value to offset our lab' camera to match the ideal height. We were pleased with the solution and the users as well, we added an extra step when they first launched the app, but we significantly improved the user experience in the long run.

New Forms of Interaction

Someone that never used a controller before is now asked to use one in each hand while blindfolded. How do we expect our users to easily jump into our experience when we give them such an obstacle in the first 10 seconds. Using a new controller is already a challenging task, learning what buttons do what, coordinating our fingers, creating a mind map of our desired actions to the controller inputs. For VR we ask them to do that for both hands, and then we place a headset covering their eyes so that they can't even see the controllers. Nevertheless, controllers are still a great way to connect with the virtual world, giving us a way to see our hands and interact with all sorts of objects in various forms.

It was not too long ago that hand tracking was added to Oculus Quest, bringing a new era to VR and how users interact with the virtual worlds. Being able to use our bare hands to grab an object is surely the pinnacle of a frictionless experience. With hand tracking our users no longer have that barrier between a real and a virtual action. Since our experience portrays real procedures, we want them to be as close as possible to reality, and granting our users the possibility of using their hands pushes our experience towards this goal.



"With hand tracking learners no longer have a barrier between a real and a virtual action"

When building our interaction framework, we made sure to make all interactions possible with both hand tracking and controllers.

With new mechanics comes new challenges, and hand tracking brought us a good share of them.

As with any new feature hand tracking has its limitations, the most obvious being the loss of tracking. Oculus Quest developed a new method of using deep learning to understand the position of the user fingers using just its monochrome cameras. Although this is a brilliant solution for adding hand tracking without the requirement of new hardware, using just the monochrome cameras means the tracking quality isn't the best. Users must have good lighting conditions, detain themselves from making fast movements, and under no circumstances overlap their hands. These are hardware limitations and we can't do much about them, what we can do is adjust our experience and try to mitigate them.

As mentioned before, one thing we were cautious about was the placement of the tools which the user had to interact with. We made sure they never need to cross their hands when handling any of the tools. Also, due to the calibration process we now have the user always in the ideal position where their hands are visible to the cameras at all times when operating a tool or interacting with the patient.

Albeit all the precautions and focus on the detail, we can not identify all the possible problems and we need a fallback plan for when they happen. When building our interaction framework, we made sure to make all interactions possible with both hand tracking and controllers. If at any moment the player is unable to have good hand tracking, for example if they can't have proper illumination where they're at, then they can just grab the controllers and the experience will instantly switch to this new input method.

There are plenty of reasons why users might switch between input methods. In order to understand the

Hand Tracking

Natural interactions give the learner a heightened sense of embodiment and enhance immersion.

Reduces friction (no controller buttons).

Enables gestures.

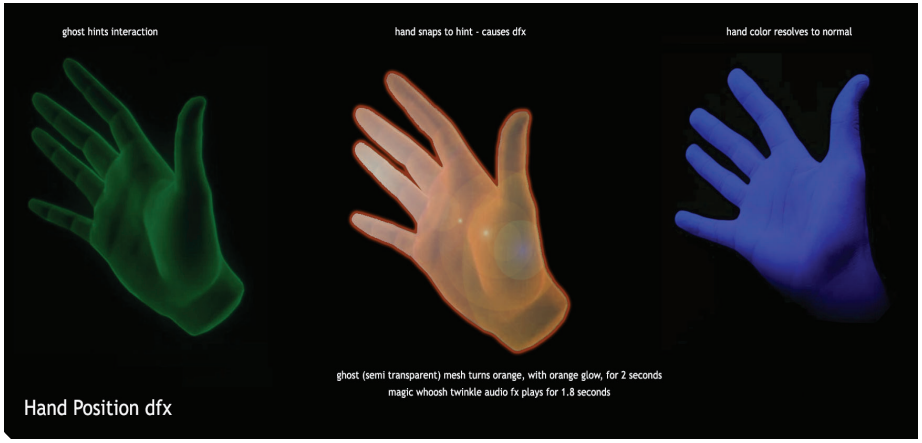
reasoning and be able to constantly improve our system, we keep track of when the user switches input systems during a session. Later we can investigate what interaction was causing them problems and if it is systematic we start the process of reworking the interaction to make it as perfect as possible for hand tracking.

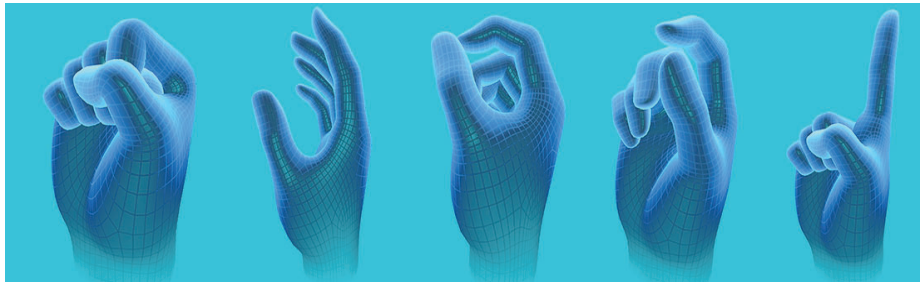
The word delight resonates in our minds every time we think about user experience. Our intent is to make all interactions as delightful as possible. Even though there's a vast list of tools our users are required to operate with, the forms of interaction fall under specific patterns which we can pinpoint and ultimately embellish to meet our intended delightful degree.

Since our users are required to do all kinds of interactions using their hands, we decided they would be ideal to portray what actions the user can do at any time. When a user moves their hand it will fade to a green color if there's a possible interaction. If they decide to grab an object the hand will then fade to a semi-transparent orange and together with a glow and sound effect it will give the user a satisfying feeling of accomplishment, even for the most trivial of actions. This is exceptionally important when using hand tracking because we don't have any haptic feedback, making visual and sound effects a must have.

Some of the user actions require more than just a grab or pinch, they involve specific hand rotations and/or movements. Considering the complexity of these actions, we can not ask the users to know what they have to do the first time they try one of our experiences.

Thus, we implemented two techniques that together aid the user in understanding the procedure. First we show what we call of hand coaching, we create an animation with ghosted hands exemplifying what motion the user has to execute. This animation repeats every few seconds and is shown until the user completes the present step. Complementing this feature we have what we call ghosted objects, these objects have a holographic look and are located on the final destination of an action, to help the user understand where they have to move the tool or object they are grabbing.

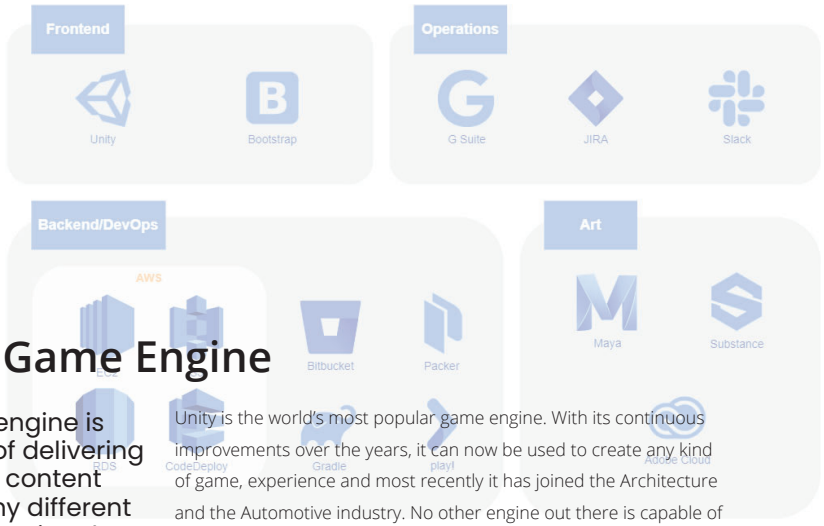




Unity, Oculus, and Pulse Engine Framework

Constant new updates, features and technologies are a certain fact in the Virtual Reality industry. Developers must keep themselves up to date with these changes in order to provide their customers with the best possible products and an excellent experience for the users. In this unpredictable field we need to choose the best tools that can provide us with some stability as well as potential to bring our products to the next level. It is also important to pay attention to what tools we affiliate with since we might become dependent on them. We most surely want to avoid spending time replacing a framework that is deeply rooted in our product. Next are some of the platforms and frameworks we use, and the reasoning behind selecting them.

When it comes to creating immersive experiences, our options for engines are quite sparse. Virtual Reality is under ongoing development and only the top engines are capable of maintaining this thriving technology.



Unity Game Engine

No other engine is capable of delivering the same content to so many different platforms using the same code-base.

Unity is the world's most popular game engine. With its continuous improvements over the years, it can now be used to create any kind of game, experience and most recently it has joined the Architecture and the Automotive industry. No other engine out there is capable of delivering the same content to so many different platforms using the same code-base. It is extremely user-friendly which makes it perfect for developers, artists and designers alike. Its ever growing community empowers every Unity user with an amazing library of resources, documentation, tutorials and forums full of helping people.

Our team has been using Unity for 9 years now, we made games and immersive experiences for Web, Windows, Mac, Android, iOS, PCVR and mobile VR. During all these years we developed a vast number of frameworks and resources which we leverage in every new project we create.

In 2012 Oculus started a Kickstarter campaign that would forever change the Virtual Reality industry. With an original goal of $250,000 they were able to raise almost $2.5 million from around 10,000 contributors. At that time Virtual Reality was not a consumer product, and Oculus surprised everyone with the Oculus Rift.

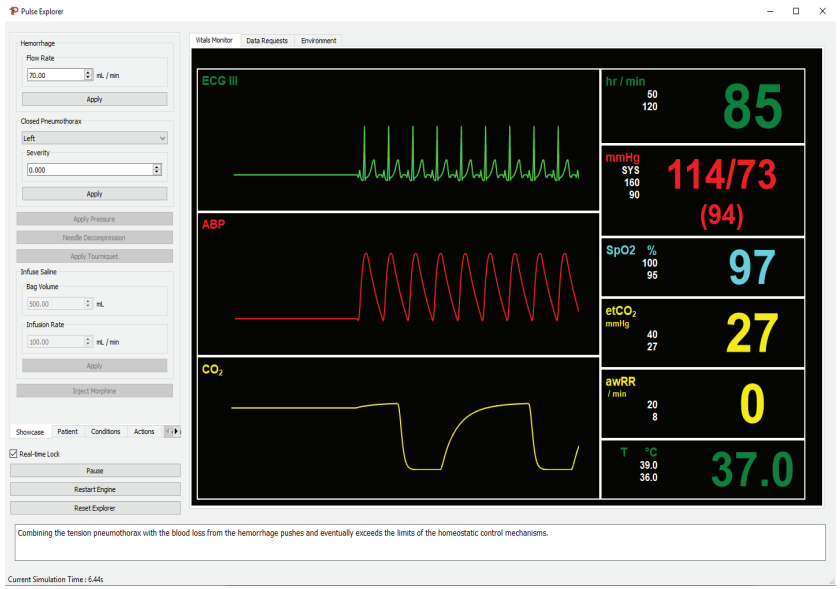
Since then Oculus was purchased by Facebook for US$2 billion, and launched a global campaign to bring Virtual Reality to every home. Fast Forward until 2018 where Oculus launched their first mobile VR headset,

Oculus Quest

the Oculus Go. This new headset was portable, with no need for a phone or a powerful computer like every other headset at that time. It was great to watch TV, movies and live events from almost anywhere. But it was a 3 DOF (Degrees of Freedom) headset, this was a clear limitation and ultimately it meant it could only be used as a 360º video player with the risk of inducing nausea if the applications tried to move the user camera.

Oculus Quest arrived in 2019 to once again shake this industry. It was the best of two worlds, it had 6DOF with inside-out tracking, meaning users wouldn't need sensors to track their headset and their hands in space. Just like Oculus Go, it was also mobile but with better lenses and processor. As we mentioned before, the Virtual Reality space is constantly changing, and 5 months after its release, Oculus was already announcing something that no one was expecting, hand tracking was coming to Oculus Quest.

We have made several projects for all VR platforms, and we strongly believe that Oculus Quest is currently the best way to bring these experiences to our users. It's the most cost effective, easy to use, feature-packed headset available.



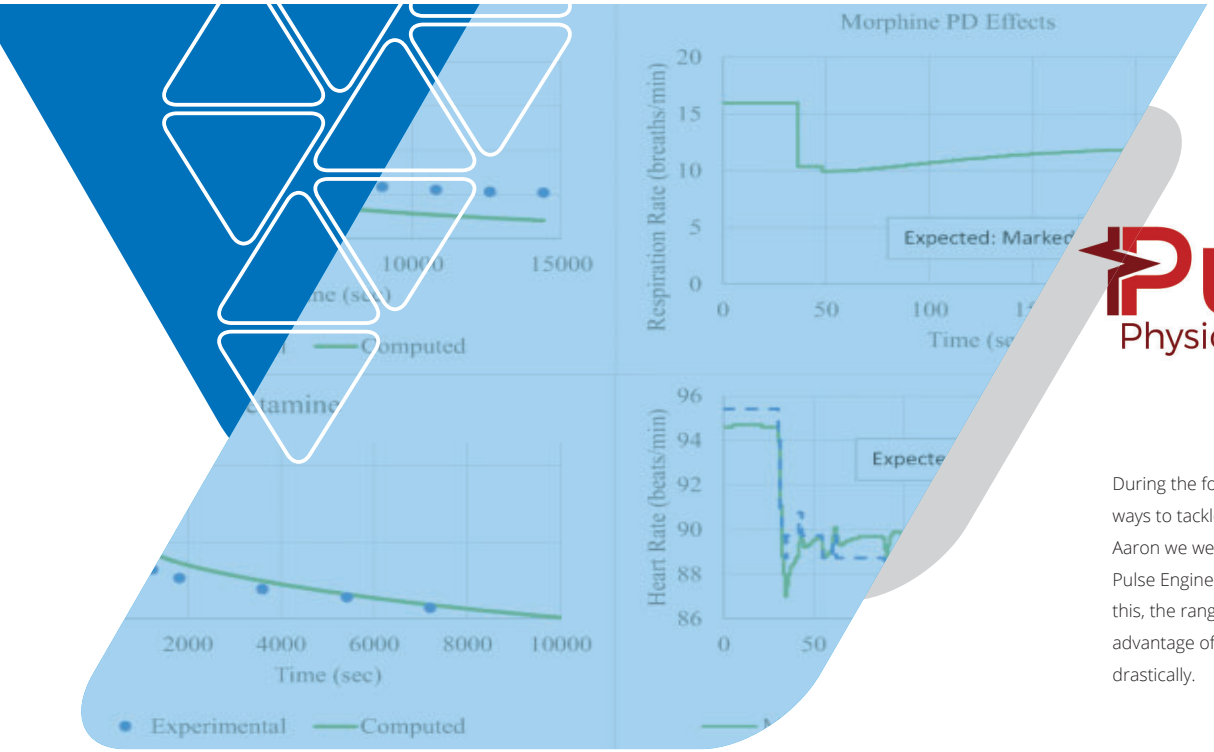
Pulse Physiology Engine

A physiology engine can contribute to a realistic training experience by producing real-time results to trauma and treatment enhancing the user experience.

In the early stages of development, we found ourselves discussing whether we wanted to create a simple system to show the patient vital signs in our labs. Amidst the discussion, we made a quick search of the current frameworks out there that we could use. We immediately came across the Pulse Physiology Engine, which would drastically impact, on the positive side, the scope of our product.

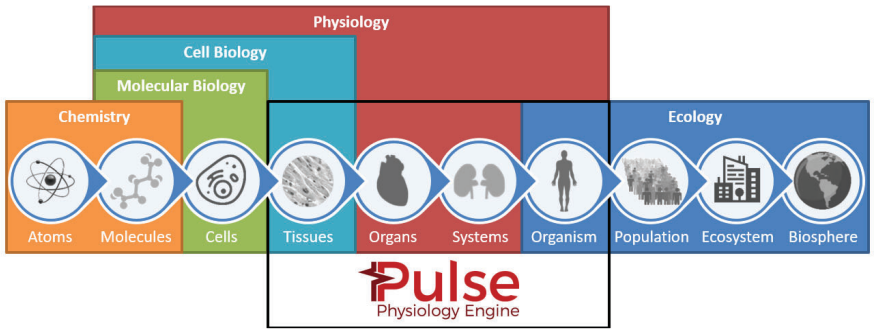
The Pulse Physiology Engine is a series of mathematical models (engine) that represent human physiology and can power immersive learning and serious games for medical training. Pulse calculates the body's response to disease, trauma, and treatment in real-time, which improves the realism of training and enhances the training experience.

The Pulse Physiology Engine is now integrated in our whole enterprise system. All our patients vital signs derive from the engine and are displayed with the utmost accuracy in an holographic panel, which we adapted from the Pulse Engine Unity SDK available on the Unity Asset Store (https://assetstore.unity.com/packages/tools/integration/pulse-physiology-engine-139773). The engine will also update the patient's vital signs based on the different procedures being done on each lab.



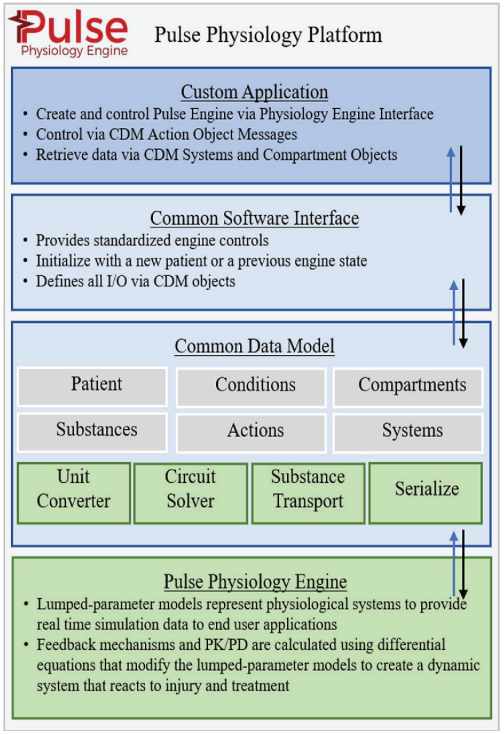
The next iteration of our product enhances our backend system to support lab customization, where administrators can define all the steps of each lab, and due to Pulse Engine potential, we can now allow them to define patient parameters, such as height, weight, systolic and diastolic pressure, as many other settings.

As we were adding the Pulse Engine to our product we faced a problem, it didn't support Oculus Quest at the time. That's when we contacted Staff R&D Engineer Aaron Bray on the Kitware discourse page (https://discourse.kitware.com/c/pulse-physiology-engine/5) where he promptly tried to help us.



Pulse Physiology Engine

During the following days we discussed possible ways to tackle this issue, and with the ingenuity of Aaron we were able to have a working version of Pulse Engine for Android in a matter of days. With this, the range of new applications that can take advantage of this amazing engine has increased drastically.

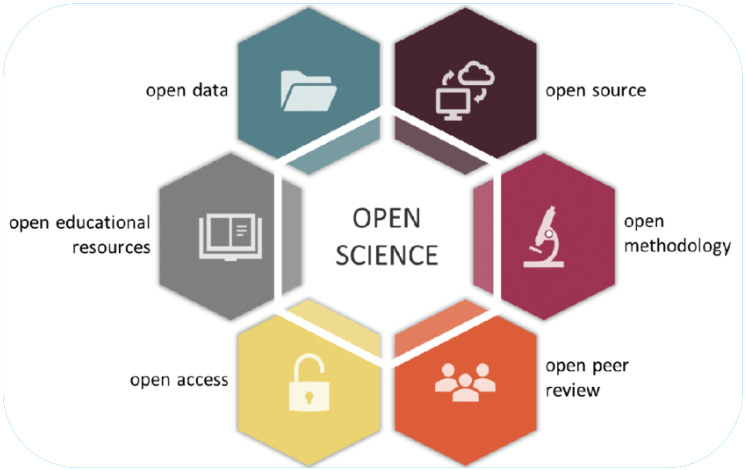


Advancing Open Science and Open Source

Kitware and Open Science

Open source software naturally supports a service business model. This model helps others make effective use of the advanced algorithmic capabilities of Kitware's software platforms, avoid vendor lock-in, and build their own solutions and internal expertise.

While Kitware encourages open source software, data sharing, and open access publications whenever possible, the company also respects the need for proprietary solutions due to competitive, privacy, security, and regulatory restrictions. Kitware will work with any enterprise to integrate its open source platforms into its products and processes, even if portions of the solution remain closed.



Kitware's open source business model has helped it create a dynamic, impactful, challenging, and meaningful corporate culture and make significant contributions to customers and collaborators. These benefits are reflected in Kitware's mission and values.

Open Source software platforms for Science and Healthcare

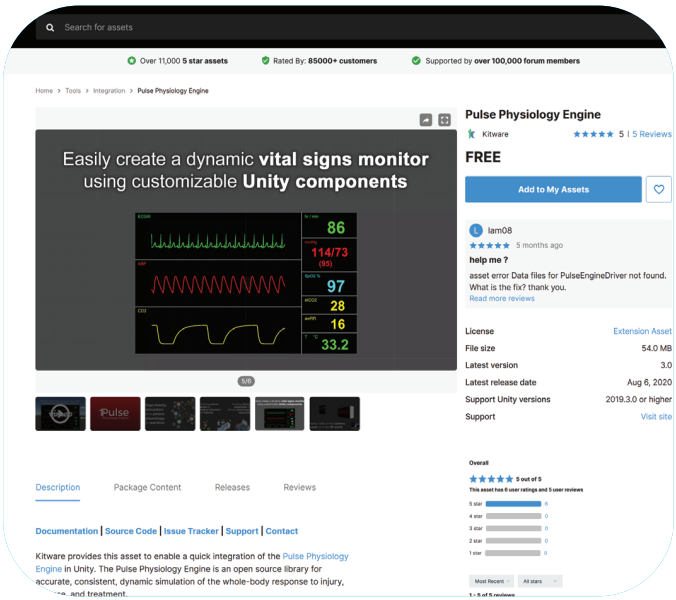
Kitware has a long history leading and contributing to open source platforms such as the Insight Toolkit (ITK) or 3D Slicer, that serve as the foundation of many medical visualization and data processing applications. Alone or as part of partnerships, Kitware generate results for research publications, generate prototypes for raising venture

Impacts of Collaboration

Kitware's platforms have promoted and benefited from extensive collaborations with academia, government, and industry. Kitware has facilitated these collaborations, in part, by distributing its platforms using open source software licenses that are not encumbered with onerous intellectual property restrictions. These licenses encourage talented developers from around the world to scrutinize the company's platforms, develop innovative solutions using them, and contribute those solutions back to them. Rigorous test and review processes ensure that contributions to Kitware platforms meet extremely high coding standards. These open licenses, world-wide collaborations, and high-quality contributions ensure that the platforms and their communities drive scientific inquiry and innovation as a matter of daily practice.

Pulse Engine - Unity Asset Store (free)

The Pulse Unity Asset is available for free on the Unity Asset Store. This Asset provides the Pulse C# API built for the Windows, Mac, Ubuntu, and Magic Leap platforms. Unity developers can easily import this assets to integrate the Pulse Physiology Engine into their Unity applications. An optional vitals monitor is also provided.



Conclusion

Immersive learning with VR can be a uniquely effective learning experience, tailored for the individual learner's experience and their personalized instructional needs. Cloud-based delivery allows for "anywhere, anytime" access, availability of practice is nearly unlimited, analytics of learning outcomes provides insight for every aspect of learner performance, and learner and class skills gaps.

Purdue University Global is a leader in immersive learning, using the Clinic Immersives NP Skills Labs Enterprise from inciteVR to provide their Nurse Practitioner (NP) learners with an affordable personalized immersive learning experience that allows them to acquire skills more rapidly, with greater accuracy, and retain the learning longer.

Kitware, Inc. is a leader in developing AI and scientific research and development solutions, powered by open source tools and applications. Kitware's Pulse Physiology Engine is a human physiology simulator that drives medical education, research, and training. It is a freely available exemplary tool for developing

effective immersive learning that leverages empathy and broadens the diversity of clinical practice experiences. It can be used as a standalone application or customized to integrate with simulators, sensor interfaces, and models of all fidelities.

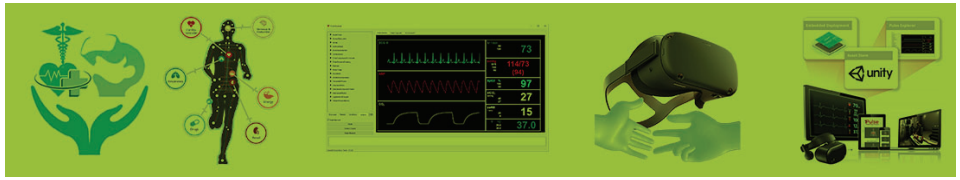
This paper reviews a subset of the myriad tools and processes used in developing immersive learning through a case study of how inciteVR incorporates the Pulse Physiology Engine developed by Kitware, Inc. in the Clinic Immersives NP Skills Labs Enterprise and the impact this has had upon the NP Learners at the School of Nursing at Purdue University Global. It explores the use of an embedded physiology engine framework to both leverage empathy and broaden the diversity of clinical practice experiences.

Moving Forward

Our goal for this paper is to share our experience using Unity, the Pulse Physiology Engine, and Oculus Quest to produce affordable and effective immersive learning that 'brings the patient to life' for clinical training.

We hope that you will find it useful and that it will ignite future collaboration within our community of practice.

We look forward to learning about your work and discussing your comments, suggestions, and questions.



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