The Coast Guard Investigating Officer Course: An Analysis and Redesign Using Immersive Technologies

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ABSTRACT

The COVID-19 pandemic impacted a wide range of military operations. However, training centers, whose operational model centers around students from across the country traveling to a single location for resident courses, were significantly impacted. To cope, the delivery of many courses was rapidly transitioned from resident to remote by way of video conferencing. Such was the case with the Coast Guard's Marine Casualty Investigating Officer Course (IOC).

Yet until recently, there was no tool available to analyze and compare the impact of this transition on the course's immersiveness and educational fidelity. Enter Ruscella and Obeid (2021) Taxonomy for Immersive Experience Design. The taxonomy presents various elements that contribute to the design of an effective immersive experience and establishes dimensions for each of these elements. Ruscella and Obeid posit their taxonomy allows designers to sequence an immersive experience, facilitating the objective comparison between experiential design and the strategic modification of those designs to achieve a specific level of immersiveness within an experience based on the environment's terminal objective(s). Proposed in 2021, there is no literature testing the taxonomy's application within an actual learning environment. This paper will do just that.

The Coast Guard's Marine Casualty Investigating Officer Course (IOC), designed around the tenants of the experiential learning theory, relies heavily on scenario-driven training modules and roleplaying. By applying the Taxonomy for Immersive Experience Design, this paper analyzes and compares the effectiveness of the Coast Guard IOC's pre-COVID-19 resident and COVID- 19 remote courses. It objectively identifies immersiveness gaps between the two courses that translate to the remote IOC's inability to deliver the authentic and immersive experience necessary to facilitate experiential learning. Further exercising the taxonomy, the paper argues that specific immersive technologies can be strategically implemented within a new virtual IOC to erase the identified immersiveness gap between the current resident and remote formats and create an immersive learning environment whose pedagogical benefits surpass that of its resident counterpart.

Keywords: Immersive Experience Design, Immersiveness, Immersive Learning, Educational Virtual Environments, Experiential Learning Theory, U.S. Coast Guard.

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The Coast Guard's marine safety mission seeks to prevent marine casualties and property losses, minimize security risks, and protect the marine environment (http://uscg.mil). To effectively execute this mission, the Coast Guard must train marine casualty investigators to staff its Coast Guard Sectors, Marine Safety Units, and Marine Safety Detachments. A cornerstone of this training is the Coast Guard's three-week Investigating Officer Course (IOC) held in residency at Coast Guard Training Center Yorktown, located in Yorktown, VA. The course provides instruction on the application of laws, regulations, and policies related to the investigation of marine casualties. Designed around the tenants of the experiential learning theory, the IOC relies heavily on scenario-driven training modules and roleplaying where students practice basic investigative techniques such as witness interviews, evidence collection, and other case processing skills. (Unites States Coast Guard [USCG], 2014, p 5). The IOC was held exclusively in residency until the spring of 2020. As the COVID-19 pandemic took hold of the nation, the Coast Guard was forced to rapidly transition its IOC from a resident course to one that can be delivered remotely while still being capable of evaluating individual performance criteria based on the course's 35 terminal performance objectives (TPO) and 227 enabling objectives (USCG 2014, USCG 2008).

Faced with time pressures to keep the training pipeline moving the course was merely modified to be delivered entirely through a video conferencing platform. The resulting remote IOC fell short of delivering the educational efficacy of its resident predecessor. Most notably, as a functional result there were three TPOs that the schoolhouse could no longer assess the student's performance on per the curriculum. These were 1) inspect the casualty scene, 2) take clear and detailed casualty scene photographs, and 3) collect physical evidence. Additionally, the experiential learning theory that the IOC is designed around was no longer fully realized in the remote format due to the reduction of immersiveness and, thus, student presence reducing course efficacy. Acknowledging these challenges as pandemic restrictions lifted the Coast Guard transitioned the remote IOC back into its residency format, forgoing the cost savings and other associated benefits of distance learning.

The ultimate failure of a permanent remote IOC was largely due to the lack of a defined tool available to guide developers in the transition to, and creation of, virtual courses. One that developers could use to ensure a virtual course retains the prerequisite student presence and course efficacy of its resident counterpart; a tool such as the Taxonomy for Immersive Experience Design proposed in 2021 by Ruscella and Obeid. This taxonomy presents various elements that contribute to the design of an effective immersive experience and establishes dimensions for each of these element allowing designers to sequence an immersive experience, facilitating the objective comparison between experiential design and the strategic modification of those designs to achieve a specific level of immersiveness within an experience based on the environment's terminal objective(s).

This paper will exercise Ruscella and Obeid (2021) Taxonomy for Immersive Experience Design to objectively identify the elements that made the remote IOC less effective than its resident counterpart, prompting its discontinuation by the Coast Guard. It argues that specific immersive technologies can be strategically implemented within a proposed "virtual" IOC to address the identified gaps between the IOC's resident and remote formats and create an authentic and immersive learning environment whose efficacy surpasses its resident counterpart. It further proposes that the presented virtual IOC contains pedagogical benefits above the resident course to include the ability to expand training scenarios, class sizes, and course frequency while still reducing training costs. The first section of this paper will present applicable immersive technologies and review the literature on immersive experiences and how they facilitate experiential learning. Next, the paper will utilize the taxonomy for immersive design to analyze both the resident and remote IOCs. The final section of this paper will present a new virtual IOC format in which these immersive technologies are implemented.

BACKGROUND

Immersive Technologies

Relevant to this discussion are the technologies and terms surrounding the creation of an immersive experience to include augmented reality (AR), virtual reality (VR), mixed reality (MR), extended reality (XR), digital twins, human-in-the-loop simulation and process-based simulations. This paper does not go into the specifics of how each technology works. Instead, it presents available technologies and terms pertinent to this paper and how they can contribute to creating immersive experiences. Of note to this discussion are human-in-the-loop and process-based simulations.

Human-in-the-loop simulation (HILsim) is a Department of Defense (DOD) term referring to a simulation requiring human inputs during runtime. In HILsims, human operators are directly controlling or playing some essential supporting function within the simulation (DOD, 2011). When modeling human-to-human interactions, HILsims utilize avatars. "Because of the human input, HILsims can model complex actions of the human domain, providing an opportunity for trainees to practice real-world complex social and human-to human-interactions" and are ideal for soft skills training (Clayton, 2020, p. 4; Likens et al., 2021).

In comparison, process-based simulations (PBsim) are simulations that do not require a human operator or human intervention during runtime. Instead, these simulations rely on algorithms and artificial intelligence to respond to user inputs and can operate autonomously without human input (DoD, 2011). When modeling human-to-human interactions within PBsims, agents which are computer-controlled characters take the place of avatars (Bailenson, 2018). "Agent-based computer simulations are individual-based computational representations extensively related to the theme in complex systems" (DoD, 2011). However, due to current technological limitations, agents are not as effective as avatars in creating suspension of disbelief during simulations modeling human-to-human interactions. (Nagendra et al., 2014).

These technologies are used in various capacities to create virtual environments (VE). A virtual environment is an artificial computer-generated environment that mimics the real world. A virtual environment allows users to interact with it and others within it in real-time "in such a way that the user suspends belief and accepts it as a real environment" (wwww.IGI-Global.com). Closely related to virtual environments are educational virtual environments (EVE) which are designed to achieve an educational objective. (Ruscella & Obeid, 2021).

Immersion and Presence

In the context of virtual environments, the work of Mel Slater is the most frequently cited when it comes to the discussion of immersion and presence. Slater and Wilbur (1997) define immersion as a description of technology. The term speaks to the objective measure in which technology, such as a computer or VR and AR headset displays, can deliver a vivid illusion of reality to the senses of the human participant while shutting out physical reality, allowing the user to become more psychologically engaged in the virtual environment (Slater & Wilbur, 1997; Cummings & Bailenson, 2016).

This psychological engagement is defined as presence. More narrowly defined for this context, presence is "the psychological sense of being in the virtual environment" (Slater & Wilbur, 1997, p. 4). Slater and Wilbur hypothesize that presence is both subjective and objective. It is subjective in the extent the user believes the virtual environment is a place and objective to the observed extent the user behaves in the virtual environment as they would in similar circumstances in the everyday reality (Slater & Wilbur, 1997). Their work is further expanded upon by Makransky and Petersen (2021), who present three factors in creating a sense of presence within a virtual environment. The first is the degree of immersion and the extent of sensory information presented to the user. The second are control factors. These include the amount of control the user has over the sensors in the environment and the degree to which the user can modify the environment and its contents. The third is representational fidelity which signifies how realistic the environment and the user's movement within it is displayed.

Immersion thus has a direct correlation to presence. The more immersive an experience, the more the technology allows the user to manifest a sense of presence within the virtual environment (Slater & Wilbur, 1997). The greater the sense of presence, the "more likely the virtual setting will dominate over physical reality in determining user responses," and the closer their behavior within the virtual environment will match their behavior to a similar circumstance in everyday reality (Cummings & Bailenson, 2016, p. 3; Slater & Wilbur, 1997).

Immersiveness

Utilizing this interplay between immersion and presence, Ruscella and Obeid have developed a taxonomy for the design of immersive experiences. This taxonomy identifies nine elements that contribute to the effectiveness of an immersive experience. Each element's depth is further expanded by introducing dimensions that specify the degree to which each element is utilized within the experience. These dimensions double as a means to score the immersiveness delivered from that particular element ranging from zero points at the lowest level to four at the highest.

Level	Interactivity	Embodiment	Co-Participation	Story	Dynamics	Gamification	Immersive Tech	Meta Control	Didactic Capacity
☆☆☆☆	Passive	Detached	Single-Player	No Story	Pre-determined	Ungamified	None	No Meta-Control	Elemental
★☆☆☆	Participatory	Watcher	One-on-One	Setting	Choice	Instruction	AR	Journey	Explicit
★★☆☆	Physicalized	First-Person POV	Secondary Perspective	Pre-Created	Multi-Thread	Reinforcement	360° media	Character	Implicit
★★★☆	Problem Solving	Movement	Group	Choose Your Own	Free Will	External Process	VR	World Builder	Recall
★★★★	Interpersonal	Human2Human Interaction	MMO	Interactive Story	Convo-Reality	Reward System	XR	World Master	Synthesis

Figure 1. A Taxonomy for Elements/Dimensions of an Immersive Experience

Figure 1 depicts Ruscella and Obeid's taxonomy for the design of an immersive experience. Represented on the x-axis are Ruscella and Obeid's nine elements of an immersive experience. The corresponding five dimensions for each element are represented on the y-axis. The dimensions are arranged from those that offer the lowest level of immersiveness within the element at the top, down to the dimensions that provide the highest level of immersiveness within the element at the bottom. The stars on the left side of Figure 1 represent the points associated with the dimension. A summary description of each elemental dimension, as proposed by Ruscella and Obeid can be found in their 2021 article A Taxonomy for Immersive Experience Design.

To apply this taxonomy, each element and its related dimensions are individually analyzed in relation to a specific immersive experience. If the experience meets the description of that dimension, it receives the corresponding points. These points range from zero at the lowest level of immersiveness to four at the highest. The total points awarded within the element yield the element's score, and the sum of the elemental scores is the immersiveness score for the experience. Dimensions are autonomous and do not require linear advancement from lower to higher levels. Although some dimensions within elements are mutually exclusive, elements may contain multiple dimensions based on the experience's design. (Ruscella & Obeid, 2021).

In essence, this taxonomy allows a designer to map the DNA of an immersive experience. In presenting this taxonomy, Ruscella and Obied do not claim that the highest score will always constitute the best fit for the experience's application. Instead, the score quantifies the immersivness potential for each element. By analyzing each elemental dimension individually, designers can objectively compare experiential designs and strategically modify those designs to achieve a desired level of immersiveness capacity within an experience based on their specific terminal objective(s).

The Application of Immersive Learning through Technology.

Immersive technologies and the EVEs they create afford numerous benefits when applied as a pedagogical tool, specifically as it related to experiential learning (Asad et al., 2021). Experiential learning is the construction of knowledge from real-world experiences. Emphasizing that the focal point of learning is the immediate personal experience, Experiential Learning Theory is based on the premise that learning is best conceived not in terms of outcomes but as a continuous process grounded in experience (Kolb, 1984). Immersive technology's ability to engage multiple senses to manifest a user's sense of presence instills behavioral response within the EVE that closely matches those of a similar circumstance in the real world (Slater & Wilbur, 1997). Thus, as a pedagogical tool, immersive EVEs create an ideal setting for realistic experiential learning opportunities.

EVEs provide the opportunity to obtain first-hand experience in situations that would be impractical, too expensive, or too risky in the real world (Asad et al., 2021). Asad et al.'s 2021 paper *Virtual Reality as Pedagogical Tool to Enhance Experiential Learning* reviews several studies on the subject, concluding that students are capable of learning by doing within an EVE and applying those concepts taught to real-life situations. Furthermore, since experiential learning requires active exploration to acquire experience, EVEs "can be an effective didactic medium by putting the student at the forefront of practical learning interactions for helping them learn experientially" (Asad et al., 2021, p12). By following the experiential learning model, concepts gained from experience within an EVE "can be converted into understanding through critical reflection or productive exploration" (Asad et al., 2021, p. 3). Thus, immersive technologies can create safe, cost-effective, and engaging EVEs in which users can closely recognize virtual experiences as direct experiences facilitating the experiential learning process (Kwon, 2019).

ANALYZING IMMERSIVNESS CAPACITY

The IOC is a three-week course consisting of lectures and scenarios designed to evaluate performance-based learning objectives. Lectures are standard PowerPoint instructor-led instruction where information is presented to the students, and the students are afforded the opportunity to interact with the instructor. Each of the scenarios consists of three components intended to mimic an investigator's actual evolution when responding to a real event. These are:

1. Accident scene processing, where the student attends one of the schoolhouse's staged accident scenes and physically moves through the environment, taking pictures, collecting evidence, and interacting with role players.
2. Witness interview roleplay where students conduct two one-on-one interviews of characters witnesses within the scenario portrayed by instructor role-players.
3. A lab component where students work independently to develop a causal analysis and complete the administrative casework and report writing for that specific scenario (USCG, 2014).

Students use the Coast Guard investigative process for marine casualties within four incident scenarios that focus on the different levels of investigations by subsequently building on each as the course progresses" (Unites States Coast Guard [USCG], 2014, p. 5). The scenarios are populated by instructor role players and played out live within one of the training center's multiple mock vessel casualty platforms, allowing students to physically move through and process a staged accident scene. These scenarios are the bedrock of the course and are used by students to practice the fundamentals of accident investigation in an experiential learning-based training environment. As the student progresses through each of the scenarios, they are evaluated individually using "GO-NO-GO" performance criteria based on the course's 35 TPOs and 227 enabling objectives (USCG 2014; USCG, 2008).

To facilitate this curriculum in the remote format, modifications had to be made to the course. A live instructor still presented lectures with PowerPoints but via a video conferencing platform, however substantial changes were made regarding the scenarios. First, the number of scenarios the students ran through on their own from start to finish was reduced to essentially one uniform scenario, which also served as the final "practical" examination. Within the scenario, instead of the student physically moving through and processing a scene populated by a live role player, they were presented with pictures, videos, and evidence from the scene for review. The live role player portion of this evolution was cut. Follow-on witness interviews, where the students are asked to observe verbal and nonverbal witness behavior, recognize characteristics of an uncooperative witness, administer oaths, and prepare a sworn written witness statement, were now done entirely over video conference. Simulating such actions as passing items back and forth and signing statements. The lab portion of each scenario remained unchanged. Students worked independently, completing casework, and entering information into the Coast Guard database; however, their geographic separation reduced the ability to easily seek guidance from each other.

The following analysis examines the immersiveness capacity of the resident and remote courses utilizing the taxonomy for immersive design. The scope of this analysis is limited to the scenario portion of the course, specifically the components relating to accident scene processing and witness interview roleplay. It should be noted that although not presented, the lecture portion of the course was analyzed. The taxonomy established that the immersive elements of lecture, whether in person or remote, were almost identical.

<u>Interactivity.</u> The scene processing portion of the resident course physically places the student within the experience, requiring them to complete participatory actions as they formulate solutions to the presented challenge while interacting with an on-scene role player. It thus possesses the dimensions of participatory, physicalized, problem-solving, and interpersonal for an elemental score of ten. The witness interview portion of the resident course also meets the dimensions of a participatory, physicalized, problem-solving, and interpersonal experience scoring ten. Within the remote course, students cannot physically walk through the scenario's staged accident scene or interact

with the role players in real-time. Instead, students are supplied pictures and videos of the scene to analyze for causal analysis formulation. Therefore, the remote course only meets the passive and problem-solving dimensions for a score of three. As witness interviews within the remote course are conducted through a video conferencing platform, they lack the physical representation of the user. However, they continue to meet the dimensions of participatory, problem solving, and interpersonal for a score of eight.

Embodiment. The resident course physically places the student in the accident scene component of the course, where they have direct control over their actions, move throughout and interact with their environment, and can explore relationships with the role player. It meets the dimensions of first-person POV, movement, and human-to-human interaction for an elemental score of nine. The same holds for the witness interview portion of the resident course, which also scores a nine. Within the remote course, accident scene processing only meets the dimensions of detached and watcher for an elemental score of one. Pictures and videos replace the student's ability to move through the environment, and there is no roleplay interaction during the student's review of such material. Witness interviews conducted over video conferencing restrict the user's movement but maintains the dimensions of first-person POC and human-to-human interaction for an elemental score of six.

Co participation. Resident course accident scene processing is complete by one student at a time with an instructor role player present for interaction, meeting dimensions of one-on-one for an elemental score of one. Witness interviews are also one-on-one as the student and role-player are the only two individuals participating in the experience at a given time. However, the interviews are recorded, allowing students to review their performance later and adding the dimension of secondary perspective for an elemental score of three. Within the remote course, students are alone with no role-player interaction as they process their accident scenes. This meets the dimension of single player for an elemental score of zero. The witness interview portion of the remote course meets the exact dimensions of its resident counterpart with an elemental score of three.

Story Setting. The course follows a consistent story within each scenario. Students are introduced to the incident after it occurred, and the cause of that incident is pre-determined by the schoolhouse. However, the student's ultimate casual analysis and conclusions and how they arrive at those conclusions are not. Therefore, the accident scene component of the resident and remote course meets the dimensions of setting, pre-created, and choose your own for a score of six. The outcome of the witness interview component is less structured. While maintaining the same overall storyline, the witness interviews do not possess a pre-created story but rather afford the student the opportunity to make independent choices that can influence the interview's outcome. The resident and remote witness interview thus meets the components of setting, choose your own, and interactive story for a score of eight.

Dynamics. As students move through the accident scene of the resident course, they are allowed to make choices about where to go, what to look at, what pieces of evidence to collect, and what pictures to take. They also engage in interpersonal communications with live role players that inform those choices within the experience. This meets the elemental dimensions of choice, free will, and conversational reality for a score of eight. Students of the remote course, while able to make decisions regarding causal analysis based on the information presented to them, lack the ability to choose that information or where within the experience it is gathered from. They also lack the ability to interact with roleplayers. Therefore, the remote accident scene component of the course only meets the dimensions of pre-determines and choice for a score of one. The witness interviewing component of both resident and remote courses meet the dimensions of choice, free-will, and conversational reality for a score of eight.

Gamification. Before commencing each scenario, students are given a set of guidelines to follow during accident scene processing and witness interviewing. They are also given a set of rules to interact with the experience as they progress through each module centered around the course TPOs (need to take pictures, collect evidence, build rapport, etc.). These TPOs are graded on a GO-NO-GO basis by the instructor, and feedback is presented to the student directly after each module. This is the same for the resident and remote course, with both accident scene and witness interview experiences meeting the dimensions of instruction, external process, and reward system for an elemental score of eight.

Immersive tech. The resident course utilizes live-action simulations and thus does not earn any points for immersive technology in any of the analyzed components. As with the resident course, the remote course received no score for immersive tech. The lack of immersive tech, in this case, was not due to it being played out in live-action simulations but rather because no immersive technology as defined by the taxonomy (AR, 360 videos, VR, XR) is incorporated into the course.

Meta control. In both the resident and remote courses, students do not have any control over the experience itself, such as what events they can participate in, or control over their character. Therefore, no points are earned for meta control in any of the analyzed components.

Didactic capacity. As the student progresses through each scenario, they are asked to incorporate multiple ideas and develop complex solutions when determining their casual analysis of the incident. As such, the accident scene processing and witness interview portions have elemental dimensions of implicit, recall, and synthesis for an elemental score of nine. This holds for both the resident and remote courses.

The side-by-side results of this scoring are displayed in Tables 1 and 2. Upon review, an objective reduction of immersiveness can be observed within the remote IOC. Specifically, the accident scene processing portion of the course sees a 43% decrease in its immersiveness score and thus its immersiveness capacity. Interactivity, embodiment, and dynamics account for most of this decrease. Although not as drastic, the witness interviewing portion of the remote IOC also saw a decline in overall immesiveness centered around the elemental reductions of interactivity and embodiment.

Accident Scene Processing		
Element	Resident IOC	Remote IOC
Interactivity	10	3
Embodiment	9	1
Co-Participation	1	1
Story	6	6
Dynamics	8	1
Gamification	8	8
Immersive Tech	0	0
Meta Control	0	0
Didactic Capacity	9	9
Total	51	29

Table 1. Residential and remote IOC Immersivness comparison of Accident Scene Processing

Witness Interview		
Element	Resident IOC	Remote IOC
Interactivity	10	8
Embodiment	9	6
Co-Participation	3	3
Story	8	8
Dynamics	8	8
Gamification	8	8
Immersive Tech	0	0
Meta Control	0	0
Didactic Capacity	9	9
Total	55	50

Table 2. Residential and Remote IOC Immersivness Comparison of Witness Interviewing

The remote IOCs observed reduction in immersiveness translates to a reduced capability to effectively realize the elements of experiential learning. Recall that immersiveness and presence are directly related. A drop of immersiveness reduces the user's ability to manifest a sense of presence within the EVE. Reduced presence means the EVE will have a reduced ability to dominate over the user's physical reality in determining their responses. As a result, there will be a divergence between how the user acts in the EVE and how they would act in a similar circumstance in the real world. As experiential learning is "learning by doing," the student's ability to link new experiences to prior ones is paramount to "understanding their current and future workplace activities in personally meaningful ways" (McCarthy, 2010; Yardley et al., 2012, p. 4). Yet, for this to occur, the experiences acquired during training must closely match those experienced in the field. The reduction of the remote IOC's ability to deliver an authentic and immersive experience not only negatively affects the learner's level of presence but the efficacy of the initial experiences offered through the training scenarios. The reduced ability to expose the learner to real-life experiences in training results in the knowledge generated within the training environment no longer effectively translating to their real-world applications.

Now that the course's "DNA" has been sequenced, designers can incorporate relevant, immersive technologies to strategically modify the experience's traits (the individual elements of an immersive experience) from the element's dimensional level to create an experience that meets their terminal objectives. In the case of the IOC, the terminal objectives are outland in the curriculum's 227 enabling and 35 TPOs (USCG, 2014).

THE CASE FOR INCLUDING IMMERSIVE TECHNOLOGIES WITHIN THE IOC

The following is a proposed virtual IOC. Much like the remote IOC, the virtual format encompasses the cost savings and flexibility of distance learning. However, utilizing the taxonomy for immersive experience design, the virtual IOC includes immersive technologies deliberately chosen to create a course that matches or exceeds the immersiveness capacity of its resident counterpart to manifest greater user presence critical effectively realizing the elements of experiential learning and the creation of a more effective learning experience. As with the analysis above, the scope of these improvements encompasses the scenario portion of the course specific to accident scene processing and witness interviewing.

Accident Scene Processing Within a Virtual IOC

The significant disadvantage of the remote course regarding accident scene processing is the student's inability to physically move throughout the accident scenes, take pictures, gather evidence, and engage with the scene's role-player in real-time. However, several technologies could facilitate this within a virtual course.

The most basic is the use of a digital twin. Using a 3D camera, the schoolhouse's already developed accident scenes can be rendered and saved within an open-source virtual world such as Matterport (Matterport). Although the student would be unable to interact with this photorealistic environment, the application of this technology would allow the student to place themselves within the accident scene using a Coast Guard standard-issue workstation or VR headset. While falling short of the full residential course experience, this technology would, quickly and inexpensively, produce learning opportunities the remote course lacks. Within a digital twin, students would be able to practice skills, such as identifying what pertinent information could be collected and taking screen captures to create photographs of the scene, satisfying the photography TPO that could not be assessed in the remote course.

A more immersive, albeit labor and cost-intensive approach would be the development of accident scenes within VR. A virtual accident scene would allow students unrestricted freedom of movement within the environment. Furthermore, students would be able to interact with and manipulate the environment to practice collecting evidence, taking measurements, and taking photographs. An EVE such as this could be inhabited by multiple users at once, including both students and roleplayers. Virtual in nature, these accident scenes are not restricted by physical space limitations. This allows the schoolhouse to create scenarios focused on larger vessel platforms. Moreover, there is no physical limitation on the number of scenarios that can be developed, enabling the schoolhouse to amass a scenario library for both current and former students to practice in. This technology, as described, has already been deployed and is currently deployed by Embry-Riddle Aeronautical University in their virtual crash lab. Designed as an interactive device and platform agnostic program that can be used online or off, the crash lab allows students to investigate the accident scene, take photos and measurements, identify and collect key pieces of evidence, and interview witnesses, all within a virtual environment. The crash lab utilizes levels, achievements, and demonstrations of accomplishments to increase student engagement. Furthermore, the crash lab allows students to witness the crash from the flight deck and listen to key dialog between pilots and air traffic controllers, affording students the ability to observe, in retrospect, whether the conclusions of their investigation were correct. The implementation of an accident scene EVE such as Embry-Riddle's crash lab within a virtual IOC would have profound impacts on the course's immersiveness potential, as analyzed below.

Figure 3. Embry-Riddle Virtual Crash Lab Screen Shot

With this addition, the scene processing portion of this virtual IOC would have interactivity dimensions of participatory, physicalized, problem-solving, and interpersonal. Embodiment dimensions would include detached, first-person POV, movement, and human-to-human interactions. The detached dimension comes from the ability to record the student's movements and actions within the virtual environment for later review. Although not carrying a score within the taxonomy, it does have a learning benefit realized through the enabling of reflective observation. Co-participation dimensions include one-on-one and secondary perspective. Again, the secondary perspective comes from the virtual course's ability to record the student's actions within the experience to facilitate metacognition. Additionally, this capability would allow instructors to process an accident scene within the EVE, record how it is done, and augment their lecture on the subject by presenting that example within VR fulfilling the group dimension of this element. Story in the proposed virtual IOC has the dimensions of setting, pre-created, and choose your own. The Dynamics element has the dimension of choice, free will, and conversational reality as the student can interact with a role player while processing the scene. However, with a library of scenarios created in the EVE, all with the same learning objectives, the curriculum could be altered to allow the student to choose scenarios that more closely align to real-world incidents they will face in their unit's area of operations, thus meeting the multi-thread dimension. Gamification dimensions of the virtual IOC include instruction, reinforcement, external process, and reward system. The EVE gives the schoolhouse the ability to imbed reinforcement within the accident scene portion of this course. Within the EVE, the created accident scenes could be accessed through desktop applications, which don't score within the immersive technology dimension, or VR. As a learning environment, there is no meta control afforded to the student, nor does there need to be. Finally, the element of didactic capacity meets the dimensions of implicit, recall, and synthesis. Table 3 depicts the virtual IOC's accident scene immersiveness score compared to the resident and remote courses.

Witness Interviewing Within a Virtual IOC

Although the witness interview portion of the IOC did not observe as drastic of an immersiveness drop between the resident and remote format, the introduction of human in the loop (HILsim) and process-based simulations (PBsim) by way of avatars and agents would produce several significant educational benefits to the course.

HILsims would be easy to incorporate within the virtual IOC's witness interview modules with minimal cost. With the instructor in direct control of the simulation, this technology allows the schoolhouse to model complex human interactions, such as those required during an investigatory interview, to mimic the interactions and results of live roleplaying (Clayton, 2020; Lee et al., 2021). The addition of HILsims within the IOC would also allow teaching capabilities beyond those afforded by live roleplaying. Since the instructors will be represented by avatars, HILsims allow greater flexibility in modifying the scenario. An avatar's gender or race can be easily altered, allowing a single instructor to play multiple roles. The interview setting can also be changed within HILsim to create greater realism in the course. "Additionally, HILsims allow the human operator to scale-up or scale- down the level of interpersonal challenge as the simulation is progressing. In other words, the rate, tone, pitch, inflection, and non-verbal communication are part of the desired skill or behavior and can be changed (scaled-up or scaled-down)" (Clayton, 2020, p. 4). The student would no longer interact with an instructor they are personally familiar with acting in a role they might not fit. The inclusion of such technology would thus create a greater suspension of disbelieve "or sense of presence in the moment within the trainee, lending to the authenticity of the scenario" (Clayton, 2020, p. 4). HILsims would also allow a single instructor to play multiple characters within a scenario within a virtual environment. This would alleviate coordination issues between instructors and scheduling conflicts for break-out rooms. Lastly, this technology would afford the schoolhouse greater flexibility in designing each scenario. At present, scenarios are developed in a gender and age neutral manner so that either a male or female instructor can roleplay the character. With the incorporation of HILsims, scenarios can be more specifically designed, requiring less effort for the schoolhouse and more realism within the scenario. HILsims are already being used within U.S Army, Air Force, and Navy soft skill-focused training courses such as sexual assault and harassment prevention and response, suicide intervention, and public affairs with great success.

Figure 4. Example of Avatar Modification

Another option is the inclusion of process-based simulations (PBsims). PBSims allow for the automation of the witness interview portion of the course. With PBsims, students could progress through the scenarios at their own speed and on their own schedule as an instructor does not need to be present. For example, the Showa Foundation created a successful PBsim that models a conversation with a Holocaust survivor in a standard question and answer interview format. To accomplish this, the survivor was interviewed while surrounded by multiple cameras affording the ability to recreate their video image in 3D. The individual was then asked every conceivable question regarding their experience. Their answers were recorded and cataloged. Using artificial intelligence (AI), the PBsim analyses the question being presented by the user and retrieves a cataloged response that most closely matches it. The AI can be continually refined over time based on the range of questions asked to create a succinct PBsim (USC Shoah Foundation; CBS, 2021). To create a further suspension of disbelief, a PBsim implemented within the virtual IOC could utilize actors as their virtual models turned agents. Although this would allow for greater flexibility with course scheduling and delivery, PBsims have disadvantages. At this time, creating a PBsim, such as the one described above, is more labor and cost-intensive than a HILsim. In addition, when simulating human-to-human interaction, PBsims are not as smooth as HILsim or live roleplaying, leading users to protentional become aware they are conversing with a program (Nagendra et al., 2014). Finally, a PBsim, as described above, is relatively rigid, and any update or modification to the scenario may require the potential re-recording with a live actor. Both HILsim and PBsims can be deployed across a wide range of immersive technologies to include desktop computers, AR headsets, and VR headsets. Additionally, PBsims are designed to be displayed via hologram technology as a three-dimensional freestanding projection that can be seen without special equipment such as glasses or head-mounted displays.

By incorporating either HILsims or PBSims, the witness interview portion of the virtual IOC would have interactivity dimensions of participatory, physicalized, problem solving, and interpersonal. Embodiment dimensions would include detached, first-person POV, movement, and human-to-human interactions. As interviews are conducted within a VE, movement is achieved virtually using VR headsets. As with scene processing, the detached dimension comes from the ability to record the interview to facilitate metacognition. Co-participation dimensions include one-on-one and secondary perspective. Story in the proposed virtual IOC has the dimensions of setting, pre-created, choose your own, and interactive story. The Dynamics element has the dimensions of choice, free-will, and conversational reality. Gamification dimensions of the virtual IOC include instruction, reinforcement, external process, and reward system. Again, using a VE gives the schoolhouse the ability to imbed reinforcement within the witness interview modules. This could be as simple as a “hot-cold” meter the instructor can control to indicate whether the student is pursuing the correct line of questioning or an automated audio/visual cue for every enabling objective the student completes. Conducted within an EVE, these witness interviews are afforded multiple mediums of access. Interviews could be completed at the most basic level using any desktop computer. However, AR headsets could project the interviewee within the student’s physical interview space, and VR could be used to conduct the interview within a synthetic space. The virtual IOC’s witness interviewing contains no meta control, and the course’s didactic capacity dimensions are that of implicit, recall, and synthesis. Table 4 depicts the virtual IOC’s witness interviewing score compared to the resident and remote courses.

Virtual IOC Advantages.

Through the taxonomy facilitated analysis of each course and the targeted implementation of immersive technologies to affect the stated learning objectives, the proposed virtual IOC observed a significant increase in immersiveness potential over its remote counterpart. Specifically, the accident processing module increased by 106%, and the witness interview module increased by 22%. Compared to the resident course, additional functionalities offered by the technology increase the immersiveness by 17% in the accident scene processing and 9% in the witness interview modules. When totaled, the virtual course immersiveness was 121, a 53% increase over the remote course’s score of 79, a 14% increase over the resident course’s 106.

Aside from increasing the immersiveness potential of the IOC and corresponding pedagogical benefits, the application of immersive technologies within the IOC also presents several practical advantages relating to the facilitation of the course. Currently, the course has three main constraints as outlined in the course curriculum.

1) The resident course is limited to 12 students per class. This is due to the number of training aids and equipment available at the schoolhouse. Examples include camera equipment, computers, and casualty response kits (USCG, 2014).
2) The resident course is limited to one class on board at a time due to limited lab space, installed equipment, classroom, and furnishings. Examples include lecture classroom space, break-out rooms for witness interviewing, and lab space and equipment for staged accident scenes and data entry portions of the course (USCG, 2014).
3) The resident course is limited to 5 convening a year due to classroom scheduling with other courses, limited training aids, lab space, installed equipment, and classroom furnishing (USCG, 2014).

Accident Scene Processing			
Element	Resident IOC	Remote IOC	Virtual IOC
Interactivity	10	3	10
Embodiment	9	1	9
Co-Participation	1	1	3
Story	6	6	6
Dynamics	8	1	10
Gamification	8	8	10
Immersive Tech	0	0	3
Meta Control	0	0	0
Didactic Capacity	9	9	9
Total	51	29	60

Table 3. IOC Immersivness comparison of Accident Scene Processing

Witness Interview			
Element	Resident IOC	Remote IOC	Virtual IOC
Interactivity	10	8	10
Embodiment	9	6	9
Co-Participation	3	3	3
Story	8	8	8
Dynamics	8	8	8
Gamification	8	8	10
Immersive Tech	0	0	4
Meta Control	0	0	0
Didactic Capacity	9	9	9
Total	55	50	61

Table 4. IOC Immersivness comparison of Witness Interviewing

These constraints were carried over when the course was transitioned from a resident to a remote format mainly to maintain the course's 2:1 student to instructor ratio and manage the learning curve both instructors and students had to undergo when operating in the remote format. However, with the introduction of immersive technologies, these course limitations disappear, and new opportunities are made available to further increase course effectiveness. Aside from the realized cost savings from no longer needing to transport, feed, and house students, the virtual IOC, as proposed, relieves all physical training facility space and equipment requirements currently constraining the course (Burgess and Moran, 2015). Furthermore, it alleviates the need for instructors to be present during the entirety of the students' progress through the course. With these constraints lifted, larger class sizes, more frequent courses, or rolling course start dates could be provided to the fleet. This would allow for the increased capacity of the IOC during peak times of demand, such as the Coast Guard's permanent change of station season and provide units the flexibility to dedicate members for training at a time convenient to their operational constraints. Finally, the proposed virtual IOC affords the opportunity to create scenarios incorporating larger and more varied platform types to expose students to a broader range of incidents they may come across in the fleet. These scenarios can be housed within a scenario library to be accessed and utilized by students for initial training and the fleet for refresher training. Qualified investigators who transfer to a unit that experiences casualty types they are not accustomed to, such as parasailing incidents, would have the ability to access the scenario library and practice their response to such incidents in an immersive, low-stress training environment.

CONCLUSION

The application of virtual environments and immersive technologies within education will continue to accelerate as the cost to implement such technologies decreases. As organizations capitalize on the advantages afforded by such technologies to augment or replace existing training courses, they must first analyze and identify the course's elements of immersiveness. Only then can a comparable virtual course be designed to meet or exceed the original's training efficacy.

This paper has demonstrated the Taxonomy for Immersive Experience Design as an effective tool for mapping and quantifying the immersive elements of an EVE and guiding one's design. Through the analysis of the Coast Guard IOC's transition from resident to remote, objective reductions in interactivity, embodiment, and dynamics are observed. These reductions resulted in the course's failure to achieve the curriculum required levels of these elements, its inability to achieve the same efficacy as its resident counterpart, and ultimately its discontinuation by the Coast Guard.

This case study demonstrates the importance of designing virtual learning environments with immersiveness in mind and the Taxonomy of Immersive Experience Design in guiding such design. The DNA of immersive design, the taxonomy affords designers thirty-six individual options across nine categories to alter the experience's characteristics through the strategic inclusion of various immersive technologies. This was exercised in the creation of a virtual IOC. To offset the identified immersiveness shortfalls within the remote course's interactivity, embodiment, and dynamics elements, the immersive technologies of HILsims, PBSims, and VR were introduced within a virtual IOC. These immersive technologies were explicitly chosen to afford the user human-to-human interaction, movement, problem-solving, and an interpersonal relationship with the environment. All conditions required to accomplish the learning objective of the original curriculum yet not present in the remote course.

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