Making Memories for a Lifetime

Content Framework for Applying Mixed Reality to Entertainment Education and Training

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ABSTRACT

This chapter explores how Mixed Reality (MR) allows the magic of virtuality to escape the confines of the computer and enter our lives to potentially change the way we play, work, train, learn and even shop. Case studies demonstrate how emerging functional capabilities will depend upon new artistic conventions to spark the imagination, enhance human experience and lead to subsequent commercial success.

The Media Convergence Laboratory at the University of Central Florida is creating a content framework for applying Mixed Reality to Entertainment, Education Training and Rehabilitation. Utilizing classical concepts of mimesis and state-of-the-art experiential entertainment, new models are examined and evaluated that will shape the next generation MR content. The convergence of story, play and games become the cornerstones of "Interplay Conventions" that will transform MR technical capabilities into new creative possibilities ("The Evolution of a Framework for Mixed Reality Experiences" is the technical companion piece).

KEYWORDS:

Mixed Reality, Virtual Reality, Augmented Reality, Interactive Entertainment, Education, Training, Story, Game, Free-Play

INTRODUCTION

Virtuality can simulate worlds with great realism or as far-fetched fantasy, yet it remains a disembodied experience trapped in the box of the computer or venue and echoing the limitation of traditional passive media. The power of mixed and Augmented Reality expands the dynamics of Virtual Reality (VR) by fully engaging the physical world (Figure 1). The more we can effectively melt the boundaries between the realities, the more we can leverage the best of both worlds. Integrating the art and science of Mixed Reality (MR) enables the power of VR to expand its impact on an unlimited number of human experiences. Its full potential will be realized when we integrate the full imagination into real and virtual worlds using emerging artistic conventions.

Our approach to enhancing human experience through MR focuses on the time-tested conventions of story, game and free-play that have been shown to appeal to the broadest demographic. However, it is important to distinguish between traditional conventions that transcend media and those that do not adapt to the new functionality of Mixed Reality (Stapleton

& Hughes, 2006). As diverse as our case studies are, they all come down to a common denominator—making memories for a lifetime (Hughes et al., 2005).

Making memories is the business of entertainment, training and education. In the case of cognitive rehabilitation we are tapping existing memories, where new ones are hard to create. Making memories is the power of imagination that can change lives (education), save lives (training), provide alternate lives (entertainment) or resurrect lives (rehabilitation). Media employs the expanse of the human imagination to define our culture, inform our understanding and spark our vision of the future. Imagination is where every medium takes its mimetic[1] form from Aristotle poetics to the latest amusement park simulation ride. For Mixed Reality to reach its full potential, we must think of it "not as a tool, but as a medium," as Brenda Laurel did with virtual reality prior to the explosion of the home video games market (Laurel, 1991).

"Think of the computer, not as a tool, but as a medium."

--Brenda Laurel

Getting the Genie out of the Bottle: Applying the Best of all Realities

The magic of media is to make technology disappear. For virtuality to escape the confines of computers, we must look beyond technology to complete the illusion for the audience. Former Disney Imagineer and video game designer, Jesse Schell, describes the role of entertainment as it applies to magic of media, "interactive entertainment creates significant overlap between perception and imagination, allowing the guests to directly manipulate and change the story world." What can we learn from other forms of interactive entertainment in MR applications to engage the imagination? Schell elaborates that "in a good interactive entertainment experience, the guest forgets that the interface exists." In this transparency, imagination is taken for granted when transforming MR from a functional tool to an expressive media form. Transforming MR will take an evolved interactive framework that leverages both new capabilities and traditional forms of interactive entertainment and the imagination. When reviewing Milgram's Reality to Virtuality continuum diagram (Milgram & Kishino, 1994), imagination is explicitly missing.

Our research objective is to expand the notion of Milgram's Mixed Reality Continuum to include imagination within a Mixed Fantasy Continuum (Stapleton & Hughes, 2003). This effort involves both the creation of a real-time technical framework of a *Mixed Reality Software System* (Hughes et al., 2005) in conjunction with developing a creative content framework of *Interplay Conventions* to transform MR into a compelling and expressive media. To understand more of the technology behind these case studies, refer to the companion chapter, "The Evolution of a Framework for Mixed Reality Experiences." Understanding that there will always be technical limitations to any new capability, we took a fresh perspective to the content framework. Throughout media history, it has been new artistic conventions that have allowed media to overcome the technical limitation and engage the human imagination to fill in where technology leaves off. There are other interactive entertainment forms that seem to transcend new media invention and form the underlying structure from which to create a new MR content framework. How can we integrate traditional interactive entertainment to leverage the emotional engagement of story, the participatory involvement of play and the procedural mechanism of games to help make memories for a lifetime?

Making Memories for a Lifetime

Whether dealing with a traumatic experience or enjoying a Disney classic, our minds are able to capture real or fictional experiences that we may want to or can't help but recall later in life. In

producing experiences for entertainment, education or training one needs to create a lifetime memory that people can effortlessly recall in order to share with a friend, reach a goal, or even save a life. What are the salient qualities of Mixed Reality that cannot be achieved with movies, video games or virtual reality?

Mixed Reality media allows us to embed virtuality into the places where we live, work and play and thus influence the physical, social and emotional aspects of our lives. To introduce this technology, we discuss an entertainment form much older than video games, television, cinema or the printing press; this is the power and complexity of experiential entertainment handed down from Aristotle's theories of mimesis (imitation of reality and human experience) to modern day theme parks (simulated fantasy). The authors take on the challenge to build the next generation Mixed Reality experience by combining one author's 20 years of experience in designing and producing films, theater, games and theme parks worldwide with the other's 40 years of experience in designing and building large-scale computer systems. We have partnered with key subject matter experts from each application area to gain insights that help us produce informed solutions.

This chapter will present the case studies as a continuum of development, identifying each project's contribution within its key challenges and lessons learned. They represent a broad enough spectrum to establish and validate many of the emerging "interplay conventions" that will be discussed in later sections.

CASE STUDIES

Case Study: Military Training Simulation

The first and most complex case study was to transform embedded training for dismounted soldiers for the United States (US) Army's Research Development Engineering Command (RDECOM). This effort starts with the hypothesis that future military ground conflicts are most likely to take place in urban terrains. To properly train dismounted infantry in Military Operation in Urban Terrain (MOUT) requires training within a simulation that comes closest to combat reality. This requires creating an extreme situation that presents a richly layered, multi-sensory experience simulating a complex environment (Figure 2). It requires situational awareness as well as rapid response in all directions, dimensions and realities to stay alive. Each domain of simulation (virtual, live or constructive) is critical, but singly cannot achieve the intense physical, cognitive and emotional intensity of combat reality. Live simulation is compelling, but expensive and laborious to mount. Virtual simulation is dynamic and easily enabled, but provides a limited perspective that is far from a realistic experience. Constructive simulation provides the perspective of the larger theater of military engagement, but traditionally only uses two-dimensional representations with cryptic icons. RDECOM requested a cross-domain solution (mixed reality) that was able to utilize the latest technical developments of MR and the compelling nature of experiential entertainment developed for venues such as theme parks, video games and extreme sports.

Building an MR application for combat training provided a need and an opportunity to develop tools to simulate scenarios within complex terrains. The end product needed to be more compelling than realistic, leveraging the power of entertainment, not as an end, but as a means. In rendering multiple realities, form, haptics, light, sound and story are integrated into one MR software system, made up of multiple rendering engines. These include a graphics engine managing visual objects and geometry; an audio engine providing a hybrid of 3D, surround, point source and hypersonic audio; and a special effects engine controlling real world elements,

similar to the use of show control to actuate devices in a theme park environment. A story engine integrates information from a sensor server; one or more physics engines; zero or more plug-ins, e.g., user interfaces and AI components; and an interactive, non-linear scenario script in order to maintain the state of the scenario and mediate the activities of the three rendering engines. The challenge in producing this system was to develop the technical framework that melts the boundaries between the realities and then develop a content framework for producing compelling experiences are both interactive and non-linear.

Pioneering use of augmented reality for military operations was achieved by registering location specific data within the physical environment to communicate critical intelligence to the soldier in a hostile environment. At the Naval Research Laboratories, the wearable system called the Battlefield Augmented Reality System (BARS) was tested for operational use within an actual battle (Julier, 2000). However, in applying similar technology to training, there were additional needs to include the entire spectrum of realities to simulate the intensity and complexity of combat reality. It is the simulation of the battle itself in addition to the communication and coordination with command and fellow soldiers (real or robotic) within a complex and dangerous terrain that requires an extreme form of Mixed Reality (Malo et al., 2004). Where the video see-through MR HMD would not be suitable for the quick action of real battle due to its resolution, field of view and frame rate, in a controlled training situation video offered the opportunity to be more convincing by filling in the gaps between the perception of real and virtual reality to provide a seamless mixing of realities.

MR MOUT Facility

In select locations across the country, entire towns are constructed as Military Operations in Urban Terrain (MOUT) sites for the armed forces to practice maneuvers within live simulations. Being heavily instrumented, they are run similar to movie studio backlots with the throughput of soldier training that is similar to theme parks. In a Science and Technology Objective (STO), RDECOM challenged us with enhancing the richness of the live MOUT training experience. In a three-year grant, we integrated art, science and engineering to experiment with the notion of a cross-domain simulation. Additional work was completed in cooperation with the Naval Research Laboratories at the Virtual Reality Labs (creators of the BARSystem).

In lieu of going out of state and experimenting within a real MOUT site, we created a mini-MOUT within the Science and Technology Training Center (STTC) at the Central Florida Research Park. It was called Mixed Reality for Military Operations in Urban Terrain (MR MOUT). Scenic sets were used temporarily during development (Figure 3). The long-term goal is to be able to develop methods and tools that could be easily deployed to make any site around the world into a cross-domain MOUT site.

Training Experience

The creation of a close-quartered combat training environment involves the design of death traps. Wearing a Canon Video See-Thru, Canon COASTAR™ HMD tracked by an Intersense 900 system, soldiers enter into a courtyard exposed to snipers and aircraft above, and surrounded by virtual threats hiding in doors and behind crates. Within reach in all directions physical walls, crates, and windows hide potential threats that must be confronted. Each real entity has a corresponding occlusion model that integrates it smoothly with virtual entities, partially occluding them and being partially occluded by them. Beyond the windows, doors and over the façades are layers of virtual urban obstructions that strategically block where you can perceive

and engage a target or where threats can spot you. The programmed unpredictable behaviors of virtual hostile forces or panicked civilians can come from anywhere in a four block diameter; from the building tops; within roaming vehicles (manned and unmanned); and hidden behind crates and doors. The soldiers must be aware of every potential threat and evaluate their optimal positions and movements with speed, accuracy and lethality. Hiding behind a crate may be the only way at first to be truly safe.

The use of hybrid chroma-keying provides additional registration accuracy for the layering of real and virtual assets. A two-tiered surround sound system provides 3D ambient and point source simulation without the need to cover the ears with headsets, thereby allowing for interaction with live audio including firearms and communications with peers via radio or in person. The multi-tiered audio allows for the registration of sound in multi-storied buildings critical to a soldier's acoustical situational awareness (Hughes et al., 2004). The reliance on just visual cues can be fatal due to the fact that you cannot see behind your head, around or through walls, but you can hear. When response times can be measured in split seconds, the training of a soldier's acoustical faculties are as important as the visual. Traditional entertainment audio assets and sound systems do not account for the range, subtleties or depths of realistic acoustical landscapes (Hughes, 2005).

Unlike your typical first-person shooter video game where your view, aim and direction of movement are the same, within MR MOUT you have a dynamic range of movement similar to live training. You have three axes of complex action (viewing, aiming and moving), which are operating in three different axes simultaneously. Virtual content is no longer confined behind embedded projection screens, nor are you separated, as in a VR HMD, from the physical passive haptics and the tangible interaction with your weapon. Other live soldiers, trainers or opposing forces can join your space. Integrated with vehicular and constructive simulation, other players working from other simulators can engage your position. Virtual entities can engage and affect real entities and vice versa. The entire training session can be captured, replayed and evaluated by behind-the-scenes trainers who can leverage multiple views, e.g., taking an observer view or positioning themselves as a virtual terrorist opposing your character, just as one would in a multi-player video game.

Lessons Learned

The MR MOUT project was an ambitious creative leap to what we feel MR should and could be. That is why it is still under development. Yet its evolution constantly feeds our other studies. For MR to work effectively, everything live and inanimate must be tracked and rendered as either a visible or occluding object. This real-time manipulation of data can be captured replayed, and used to analyze and measure performance. This capability has led to our formulating a concept we call Human Experience Modeling that combines the capture, simulation and analysis aspects of a full experience to perform After Action Review (ARR) and to create novel visualizations of aggregate data that can impact training as either a 3D immersive replay or a visualization of interactions not revealed in the heat of battle. This concept is further explored with the experience called MR Kitchen that uses MR to enhance cognitive rehabilitation.

As we transfer the lessons learned to other applications, the emphasis transfers from technical accuracy and refinement to the ability to tell a good story or play a good game. The power of interactive entertainment cannot be underestimated. However, in serious applications with life and death consequences, it needs to be used as a means and not as an end. Evolving

artistic conventions are used more for impact than they are for expression. The value of MR MOUT comes in being able to measure the impact in human performance.

Mixed Fantasy Continuum: Interplay Conventions

Once the technology is incorporated within an integrated system, the creative Interplay Conventions begin to evolve to drive an immersive, interactive and non-linear scenario both technically and creatively. Where modern conventions of cinema and video games are designed to remove you from reality, there is a need to tap traditions of live theater that have embraced the physical venue in context to the creative content. From the classical theory of mimesis[2] to contemporary video games, it is the author's alchemy of the mind, media and matter that produces the magic of simulation (Figure 4). (I) The **MIND** creates a vision (invento) that is artistically crafted (poiesis) (II) in the form of a **MEDIA** (mimenta) designed to skillfully render (techne) (III) for the reception of the audience as **MATTER** (mimema) and their imagination. (IV) With interactive entertainment, even the level of engagement or causality becomes a spectrum of creativity.

Unlike recorded media, we must also design the causality that builds the audience's investment within the story world (Mott, 2005). In passive media, the performance is from another time and place and the audience merely ***absorbs***. In an engaging live theater, the audience presence is ***proximate*** to the performance and influences the delivery. Theme park rides are active where the audience ***participates*** even if they are linear. Video Games are reactive where one ***chooses***, but everything has already been created. Role Playing Games, on the other hand, are truly interactive where the audience ***contributes*** to the story. Ultimately, you have experiential where the audience ***lives*** the experience. Prior to the convergence of real-time simulation, technology limited an artist to one level of causality or another. Now it becomes an entire creative spectrum from which to work with and discover its impact to apply to the procedural interactive story engine.

In driving the MR story engine, it is necessary to be able to create a combat mimema (singular form of mimesis) that could also build a climatic story arc. This required the creative conventions and heuristics of video games combined with techniques of interactive theater and military rules of engagement to achieve the emotional intensity to train and evaluate a soldier's competencies while under pressure. Where story is usually considered passive and linear, we need to author the program with dramatic structure within the dynamic mechanics of a scenario script.

Case Study: Entertainment

Entertainment has defined most of the emerging forms of media technology throughout history by providing an appealing introduction of novel possibilities for an unsuspecting audience. When a new capability like MR emerges, entertainment can be the ultimate qualifying factor in its ability to be applied to other mainstream applications. It is also compelling entertainment content that sparks market demand for the technology and drives the adoption across diverse applications. Unfortunately, entertainment is a reluctant adopter of new technology. This has forced major consumer electronics manufacturers to become entertainment firms to help drive the adoption of new technological products (Sony, Microsoft, Apple, etc.). The easier way to introduce new technology is not to create an entirely new model, but to reinvent an existing model. In this way you disguise a potentially disruptive technology as an acceptable innovation. Our quest to transform MR into a successful entertainment concept was a "solution looking for a problem." We needed to look for just the right problem to exemplify the unique qualities of MR to mainstream audiences.

With the convenience and economy of on-line shopping, traditional "bricks and mortar" businesses need to rethink the experience of shopping for their customers to stay competitive. They need to draw customers not only by their selection of goods, but with the entertainment experience of shopping itself, creating what has been coined "retailtainment."

"The more time someone spends in a mall, the more stores they will visit and the more they will buy" (Underhill, 2004). Adapting the advances developed with MR MOUT allows us to bring the extreme experience of a destination theme park to a local mall.

Invention to Innovation: Solution Looking for a Problem

Our partners, experts in retailtainment, Brand Experience Laboratory (http://www.brandexperiencelab.org/), brought a challenge for us to solve with MR. Their client, MGM needed to market their brand and each variation of their franchises in different retail outlets. They needed to sell feature films in the movie theaters, games in the game stores, videos in the video store, merchandise in the merchandising stores and theme park vacation packages through travel agents. How could they find one vehicle to do all this at the place where customers can actually buy all of these products when they have the propensity to spend?

Naturally, the shopping malls are where theaters and stores exist that sell all forms of entertainment, and where the customer is primed and ready to buy on impulse. The challenge was to construct an experience that could sell all forms of entertainment for all franchises. They requested content that feels like you are in a film; engages you like your favorite video game; and immerses your whole family in the experience like a theme park. This transformed into TimePortal an experiential movie trailer (Figure 5).

As an entertainment company, MGM can spend as much on marketing a film as they do on the production itself. The high-risk, big profit potential is too crucial not to emphasize marketing. Most marketing is based on the media where it is distributed. Like new movies, it was in the form of a "movie trailer," a quick synopsis of the story premise presented in the theater to set up expectations to see the film. Yet the emphasis of movie trailers now needs to go beyond just selling films. Even though films only represent a niche market of $10 billion dollars, they drive the entire $100 billion dollar entertainment market. What sells a film needs to also sell videos, music, television, games, merchandise and amusement attractions. For the movie studio, the investment made in marketing needs to sell the whole franchise, not just the movie. As entertainment companies, studios also need to sell all of their franchises in the form of brand experience marketing.

The Challenge: Retailtainment Experience

To market an entire entertainment franchise within an experiential venue, like a shopping mall, meant that the solution needed to appeal to the entire family (cross-demographic), competing within a highly competitive marketing environment that must demand the attention of the shopper in order to sell the product. With marketing, the first advantage of MR is that novelty sells. However, as just a head mounted experience, it could not draw a majority of the crowds. With only the MR HMDs, the experience would shut out the bystanders capturing only a fraction of the audience. In addition, the operation of placing HMDs on and off guests was too time-consuming and labor intensive to be considered. A new form of display and interaction was needed to address different levels of interaction with a larger amount of peripheral players and spectators.

Levels of Interactivity: Divers, Swimmers and Waders

The important aspect of experiential entertainment is that not everyone wants the same experience. However, they don't want to feel cheated by making the wrong choice and not

getting the best experience that is suited for them. To accommodate a wide variety of needs with the same content, different levels of interactivity and immersion need to be provided. In designing theme parks worldwide, one realizes that there are distinct types of attendees who like different levels of experiences. These levels are known in the industry as swimmers, divers and waders. The key is to provide each level with the appropriate entertainment value for their investment of time, money and risk. Divers making up about a fifth of any audience; they will jump right in to the center of attention and gear up in the MR HMD. Swimmers would rather participate via the portal view; they are not willing to mess up their hair for the HMD or look silly. Waders just like watch others having a good time. In this case, we needed to make the whole environment come alive with action and special effects.

The content needs to be designed with all three levels of interactivity as options, uncharacteristic of Hollywood style entertainment, where one size fits all. Each level of interactivity operates at different capacity and throughput. Where one diver's experience is typically two minutes, there could be two swimmers interacting during the same time with a peripheral audience of waders equaling two to eight spectators in the same time period.

Lessons Learned

At the 2003 international SIGGRAPH conference's commercial exhibition, the model was tested. It was intended to draw a significant crowd and sustain the anticipated capacity and throughput with interchangeable content (Figure 6). When the content was not in operation, e.g., during changeover, the crowd immediately dispersed.

For an industry where capacity is king, MR is able to expand capacity and throughput as well as providing webcast of the experience or competition. However, until the MR HMDs are in higher supply and more ruggedly built at a lower cost, the fully designed experience is impractical.

The next challenge was to see if this model could go beyond merely amusing and transfer to more challenging markets and work beyond the novelty and provide a significant functional innovation (Moore, 1991). This made us examine a more economical form of the experience without the use of the HMD. This led us to an even more challenging application for informal education or Edutainment.

Mixing Realty Conventions: Interface to Interplay

It is easy to say you will make an entertainment experience "feel like a film, play like a game and immerse families like a theme park," but the realities are that the structure of stories, games and free-play are very different forms of entertainment even though they are made up of the same components of emotions and fantasy. When designing MR experiences, we not only needed to bring story, game and play together, but needed to leverage each to provide an overall heightened experience (Figure 7). (A) The emotional power (***Pathos***) of the story provides the invitation to draw the audience into the experience and apply their imagination. (B) The irresistible simplicity of play invites physically interaction (***Participatory***). (C) The Mixed Reality Engine gives us the power of game mechanics (***Procedural***) to invite the virtual world of media to integrate with both our physical and imaginary worlds leading to social interactivity. Instead of being distracted by an explicit graphical user "interface" to structure usability, the concept of "interplay" integrates complex environments, relationships and behavior using story, games and free-play. Janet Murray (1997) similarly frames the future of interactive narrative in what she calls the ***multiform story*** which is composed of the audience's ***participation*** with the

computer's ***procedure***, for mediation of the ***encyclopedic*** ingredients of the story world including its ***environmental*** navigation of immersion.

Story World: Stories Engaging the Mind with Pathos

The user is motivated in proportion to the ability of the author to make the audience empathetic with the characters (McKee, 1997), so much so that the audience is immersed within the presence of that character and will be compelled to go wherever or do whatever the author of story directs them to do. The empathy is achieved through emotion. The emotion or ***pathos*** of the audience is engaged by the story flow that motivates their interplay between intriguing ***characters*** in context with dynamic ***worlds,*** and driven by escalating risks in ***events*** that then help transform the character and achieve an emotional catharsis, or the intent of the author.

Playground: Toys engaging Matter with Participation

Interactivity is inherently physical. When it asks us to participate, we must act by walking into, triggering effects or reacting to stimuli. Play interfaces mediate the real world to incorporate ***participation*** with the virtual and imaginary worlds. Play intuitively engages the entire body and its full range of sensory perception and visceral kinesthetic interaction, just as a playground or a toy does. Where passive media disengages the body in order to work, future interactive media must engage the audience by inviting participation within play (Wirth, 1994).

The structure of free-play involves the ***cause*** & ***effect*** that leads to ***consequences***. It defines the immediate interaction and exchange that the users employ to understand and participate meaningfully with their surroundings. There are no rules in play, nor are there winners or losers. It drives the curiosity of the users and draws them deeper into the flow of game and story play.

Playing Field: Games engaging the Media with Procedure

Where play drives the participation of the user and defines the User's Interface (UI), something must drive the procedure of the overall computer. The art of game mechanics are used in video games at a basic level of simulated mediation. Game developers use the construct of rules, tools and goals to motivate and process the exchange between real and virtual behaviors.

Goals are set to prompt a challenge for the user to engage the media. The construct of ***rules*** is for the player to act and the machine to respond accordingly, providing increasing intensity with persistent and non-linear outcomes and increasing interest. ***Tools*** are created to empower the user's influence that is motivated by the goals that are established.

Case Study: Informal Education

The strength of an innovation like MR rests in its ability to transfer across diverse applications. For military training, it was able to render rich and complex cross-domain immersion. For entertainment, it was able to draw a crowd and entertain a wide variety of users. But, how will MR transfer to a venue such as informal education? Community learning centers such as the Orlando Science Center need to compete with not only the sophistication of national museums such as the Smithsonian Institution, but with destination theme parks such as Walt Disney World and Universal Studios as well. On a fraction of the budget and a minimum ability to support complex technology, can the use of MR in informal education prove to be as if not more successful than the entertainment or military projects?

Our target application, the Orlando Science Center's Dino Digs exhibit, was not performing up to expectations. Although it is well-designed aesthetically, it became stale over time and unable to change. A cornerstone of the science center when the exhibit first opened five years ago, it showcases large and impressive prehistoric fossil displays. Yet when people come through the doors, it does not take long for them to walk right back out. "There is nothing to do," said one kid, "This is boring, let's go," said another. Although there is plenty to learn on the detailed information plaques, most people do not bother to read them. The center's CEO had few choices to solve this problem. He could leave it as is and lose money, because it would still cost him to staff it, maintain it, heat, cool and clean it. He could gut the exhibit and start over, but risked the chance of getting complaints about losing a landmark. In addition, the cost to redesign and build a new exhibit took more capital than was available. He could fill the empty space with a rented exhibit, but that venture usually costs as much as it earns. With either choice there is a lot of work and investment without much return. He needed a third option to avoid capital expense of redesign, or rebuilding, but that also increased the educational and entertainment value that would bring more people in, have them stay longer and come back on a regular basis. What could MR do to augment the experience to enhance the educational and entertainment value and draw more attendance? Could the experience draw more people more often with minimal cost and infrastructure, and change the whole economic model for museum redesign? If applied on a larger scale, could it be a model for the whole industry?

MR Sea Creature Learning Experience

As you enter the exhibit called Dino Digs, you are surrounded by prehistoric fossils in an attack position ready to devour you. Prior to incorporating Mixed Reality, there was little else to do besides read the information panels and play in some sand. The challenge was to spark viewers' interest in order to motivate them to learn more and perhaps even read the plaques to inspire learning back home or in the classroom. In the expanded exhibit, parents or kids could peer through the MR Portal (Figure 8) seeing a live video feed of the museum beyond, augmented with virtual content including a digital docent. These characters, some from live capture and others from computer generated animation, explained or demonstrated the significance of items in the exhibit. After the introduction, the venue was virtually flooded with water as seen through the portal. Prehistoric marine reptile fossils grew muscle and skin and came alive to swim around the exhibit. Users had multiple views from which to interact with the environment. Through the portal, one had a stationary augmented reality view with water and dinosaurs overlaying the exhibit and other guests. Occlusion models allowed for virtual content to flow around exhibit features, moving and disappearing behind and in-between structures. On the user's control panel, a trackball operated a virtual, unmanned underwater vehicle to explore the exhibit space for artifacts. A monitor in the podium displayed a virtual telepresence viewpoint of the underwater vehicle in order to guide the user through the exhibit to find artifacts. This would occasionally toggle to the laboratory where the paleontologist guided participants from his laboratory. The monitor also contained a heads-up display with readings of health, cargo, research references and other data. A simulated radar signal identified the spots where interesting artifacts could be found. This encouraged further investigation of the real exhibit to score better on the virtual expedition.

The experience guided participants through the physical exhibits to make the activity that much more realistic. The display provided for activities for participants to work together, enhancing the relational aspects of the experience. The experience revealed that Florida was

underwater during the Cretaceous Period when prehistoric reptiles swam the earth. The flooding was not only a dramatic movement for the participants; it also drove home the relevance that the events took place right where viewers were standing.

Validating the Design

During a one-month field study, a third party evaluator from the Text & Technology Doctoral Program at the University of Central Florida observed the exhibit, conducting interviews of the participants concerning the educational and entertainment value of the MR experience. They observed duration of interaction, surveyed the propensity for repeat visits and patronage of similar exhibits. The results showed that younger guests extended their exhibit stay beyond ten minutes and up to thirty minutes, or often until their parents pulled them away. The game encouraged exploration of other parts of the exhibit, typically to become better at the game play (Hughes et al., 2005). The most encouraging observation was how much the imagination of the audience was able to extend beyond the virtuality to areas that had no technology. Some children during the experience chose to pretend to swim through the hall versus walking.

The experience was evaluated for two weeks with over 500 guests participating in the activity. Evaluations revealed that more than 80% of a random sample of 50 guests surveyed either agreed or strongly agreed that MR enhanced the entertainment experience, added educational value, enticed them to visit similar exhibits, and encouraged extended and repeat play (Figure 9). This means that MR not only provided a better experience for guests, but enhanced the potential economic performance of the exhibit.

Lessons Learned

Mixed Reality is able to provide a critical option for museums that allows exhibits to not only keep up with the latest techniques of entertainment in video games, but also incorporate the latest scientific visualization techniques being used regularly by scientists. MR can allow the constantly changing world and advancing scientific knowledge to be directly reflected within learning institutions by having a vehicle to showcase simulated models of actual scientific phenomena drawn from current research. The video see-through technology provides a method to transfer insights from exhibit experiences into the home and classroom. MR expands the value of the unique artifacts of an institution's collections, as well as provides a continuous flow of new content to keep a museum's offerings fresh and relevant. All of this provides means for an industry struggling to survive financially to transform itself so it can compete with the growing amount of leisure activities.

Mixing realities provides a platform for the parent to become an active mentor and inspiration within the learning experience. With your parent being the most important teacher in a child's life, where does the parent learn to be a teacher? What if MR in community-learning centers can become the prime location for parents to learn and play the role of teacher with the help of dynamic augmentation of physical experience? The use of the MR Portal allows one-to-one interplay, challenges and explanations between parent and child. In the traditional exhibit, a parent cannot read information plaques fast enough to either entertain their children or keep up with questions. With the display of passive video, there is no opportunity for the parent to participate within the learning experience. In contrast, with a multi-participant interactive game, the MR learning landscape can be explored together with enough engagement to keep the attention of the child, while allowing enough time for the parent to become the guide.

These results speak to the economic impact. By enhancing the exhibit with augmented reality, museums can keep a valued collection and periodically supply new experiences without

any capital improvements. Enhanced games and content can provide added value as a rental facility. The video based technology also allows for unique photo opportunities for guests to purchase at events or email to friends as a promotion.

Interplay Conventions: Linking Story, Play and Game into learning experiences.

The traditional graphical user interface with either virtual content or physical plaques in museums tends to disrupt the playful and active flow of discovery. The distinct and sometimes disruptive inquiry based interaction with multiple-choice answers and fixed branching limits the imaginative play and personal exploration of an experiential venue. With all the types of interaction (physical, social, cognitive) happening at once, the notion of "conversationality" is needed in the next generation of interface interaction. It will need to be more subtle and implemented with more casual interruptions, responsive questions, implicit utterances and peripheral gestures to indicate understanding and propel deeper engagement (Laurel, 1993). The convention of interactive entertainment provides a very intuitive process for this exchange. However, the introduction of entertainment can be controversial when applied to education.

Working with the Communicative Disorders Laboratory at UCF's College of Health and Public Affairs, we started to construct a content framework that sequentially incorporated entertainment structures of story, play and game as a complete learning engagement. In Figure 10 we have the same underlying story, play and game interplay diagram as it applies to this learning framework. 1) The emotional impact of story allows us to create a relevant connection to hook the user and answer the prime question, "why should I care?" If the story is successful, the guest's curiosity will be sparked and the audience will begin to inquire. 2) The inquiry validates the success of the story. 3) The set up of a playful environment that invites users' participation based on their curiosity validates the success of the inquiry. Without the pressures of winning and losing, the user is provided with enough stimulus and response to understand the properties and concepts being presented in the simulation. 4) The play provides the basis for understanding, and if successful, inspires creativity in recombining the learned elements in unique and novel ways. The successful creative process validates the foundational learning from successful play. 5) The play and creativity process is validated when it leads to a higher level of critical thinking where one starts to set up experiments with the elements of games (goals, rules and tools). 6) Game play naturally brings in the process of sharing with multi-players demonstrating confidence in mastering the subject matter and culminates an experience with social interaction. The process that is driven by the succession of story, play and game building engagement, and the level of interactivity provides a powerful tool in helping change attitudes in education to increase motivation in learning.

Future Work: Human Experience Modeler

The emphasis on media has been mostly focused on the display and interaction of sensory stimulation. With the extent and precision of tracking and modeling of all the realities and interactions, that data can be captured to a high degree of detail. This captured data can then be replayed, reviewed and analyzed to rapidly evaluate participant performance. Rapid analysis and replay can significantly improve rehabilitation practices and effectively transfer training into practice

In pilot tests, we prototyped a multi-purpose Human Experience Modeler for cognitive rehabilitation (Fidopiastis et al., 2005) to explore how Mixed Reality can capture, replicate and analyze human behavior for real-time feedback and adaptation to improve human performance (Figure 11). Our work with cognitive scientists, team performance specialists and human factors engineers has led to our developing a multi-purpose integrated system that has provided

understanding and insight on how people perform a variety of tasks, hopefully leading to improved methods and performance in all aspects of life. Applications are now expanding into elite sports training, design & manufacturing, advanced decision support systems and intelligent security systems.

CONCLUSION

Invention into Innovation: Capabilities into Possibilities

The transition from invention to innovation goes beyond merely bringing a product to market. It involves applying new technology so that it can change participants' lives. This is even more significant than the invention itself. It transitions technical capabilities into creative possibilities by conducting in-depth development, experimentation and refinement within each application to understand how the invention can be best enhanced and exploited.

The power of Mixed and Augmented Reality in the future will be greater than all existing media forms put together. This is mostly because MR is the convergence of all previous media forms. It involves making creative leaps incorporating ancient traditions and inventing new conventions. We have not yet found an application from which Mixed and Augmented Reality has not been able to benefit.

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Figure 1: Concept art for Sea Creatures' Journey. Kids use the Mixed Reality Kiosk to cooperatively operate an underwater vehicle around the Orlando Science Center's Dino Digs fossil exhibit where underwater prehistoric reptiles come alive (©2006 UCF).

Figure 2: Mixed Reality for Military Operations in Urban Terrain (MR MOUT) concept art merging real and computer generated forces and assets within a physical courtyard (deathtrap) surrounded by urban combat terrain with MR views from real and virtual soldiers, observer cameras & combat vehicles (©2006 UCF).

Figure 3: US Army MR MOUT facility at RDECOM, displaying multiple real, virtual or augmented views from the operator's panel (left). Trainee observing 3D replay of the scenario with trainer (upper right). Embedded MR security camera capturing alternative views for observation (lower right) (©2006 UCF).

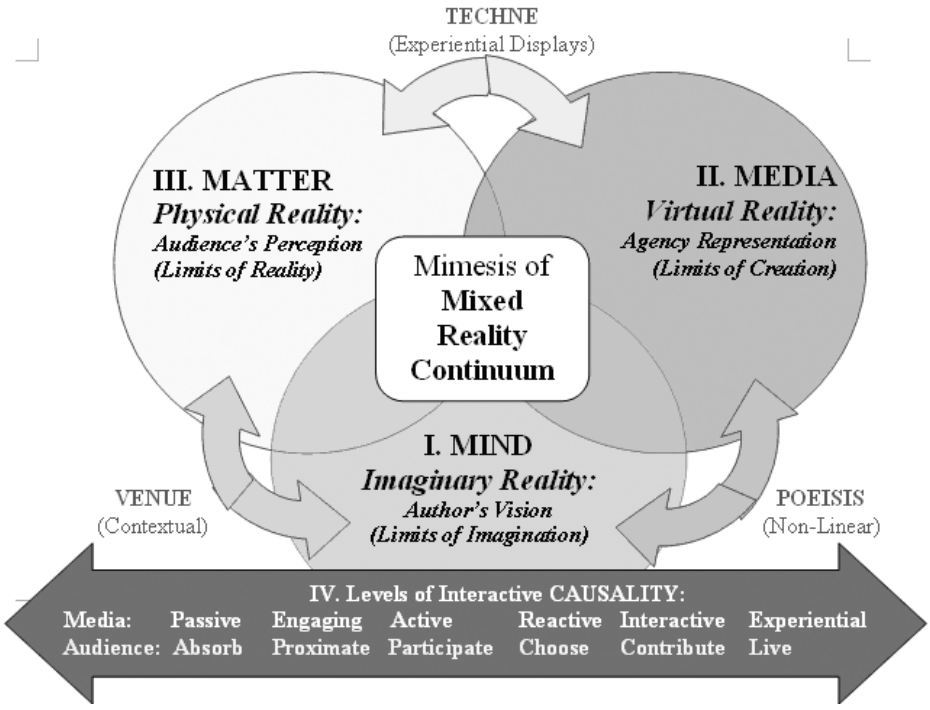


Figure 4: The Mimesis of Mixed Reality shows the relationship between classical theories of Mimesis with Mixed Reality Continuums and the levels of causality used as a foundation for next generation InterPlay Conventions (©2006 UCF).

Figure 5: Concept art for MR TimePortal, an experiential movie trailer to market MGM entertainment franchises in malls as retailtainment. Multiple levels of interactivity hook diverse participants and increase attendance capacity and through-put (©2006 UCF).

Figure 6: At the 2003 SIGGRAPH conference, TimePortal showcasing multiple MR displays including Canon's MR HMD and MR Kiosk created with Elumens Vision Domes and Canon fisheye cameras, with magnetic tracking by polhemus FastTrack (©2006 UCF).

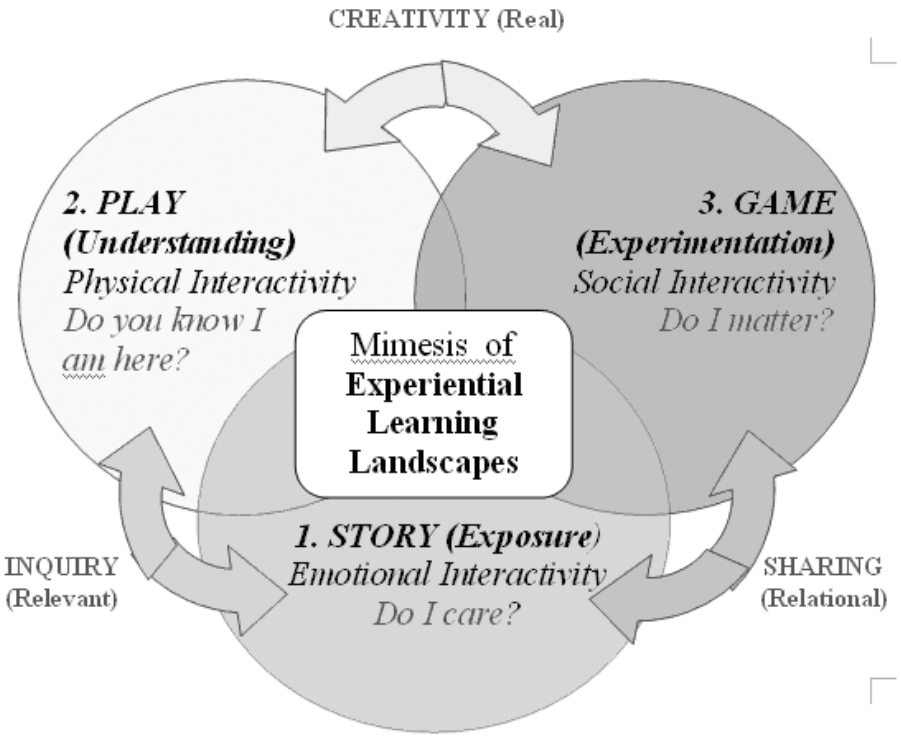
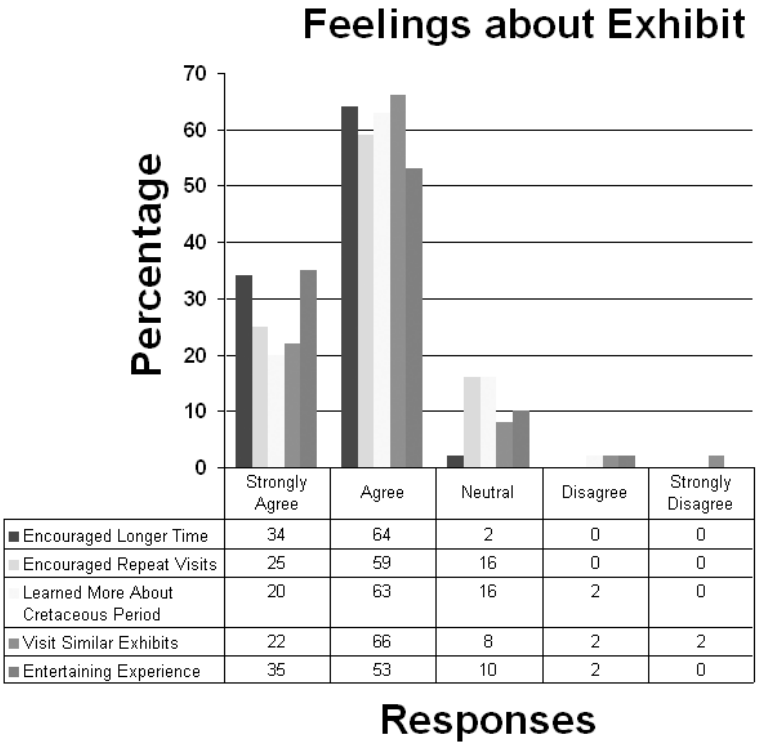


Figure 7: InterPlay Conventions of story, play and game relating the Mixed Reality Continuum to the pathos, participatory and procedural aspects computer generated scenarios *(©2006 UCF)*..

Figure 8: Users using Mixed Reality kiosk with content example for Sea Creature's Journey field testing at the Orlando Science Center's Dino Digs exhibit.



	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Encouraged Longer Time	34	64	2	0	0
Encouraged Repeat Visits	25	59	16	0	0
Learned More About Cretaceous Period	20	63	16	2	0
Visit Similar Exhibits	22	66	8	2	2
Entertaining Experience	35	53	10	2	0

Figure 9: MR Sea Creature's pilot test results show a significant increase in the entertainment and educational value with increased duration time and likelihood of repeat visit.

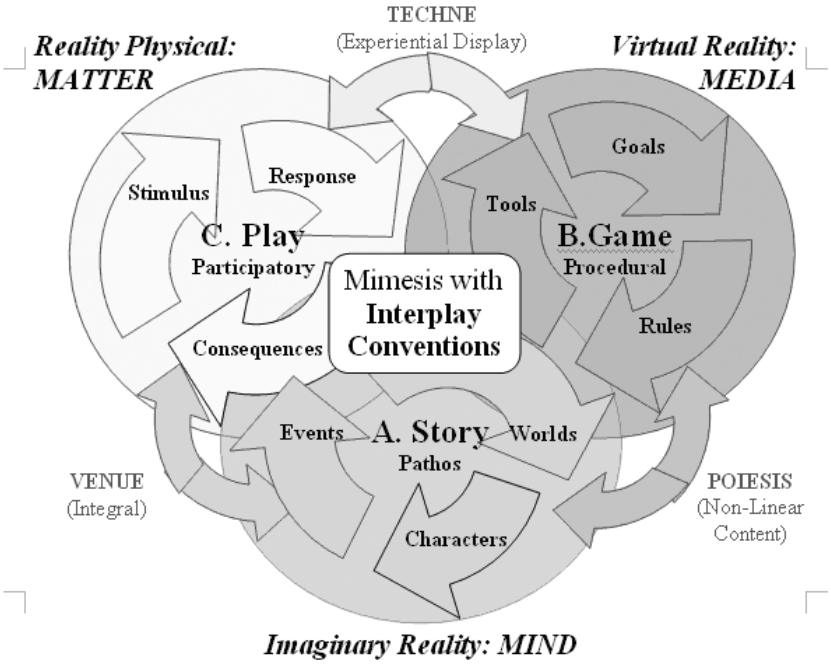


Figure 10: The InterPlay Convention as it is applied to informal education utilizing the use of story, game and play to engage in physical, emotional and social interactivity.

Figure 11: Human Experience Modeler capturing, simulating and analyzing human performance with cognitive rehabilitation for retraining of daily activities for traumatic brain injury patients.

[1] Reflective or representative of actuality or reality of human experience (derived from Aristotle's concept of mimesis or imitation).www2.cumberlandcollege.edu/acad/english/litcritweb/glossary.htm

[2] The classical concept of mimesis (Sörbom, 2002) defines the reflective or representative reality of human experience. They distinguished the virtual world as the artistic Media (a painting of Pegasus for instance) that represents both the physical Matter in the real world (a horse and a bird) as well as the vision of the artist (the mythical character). Artistic and technical methods were used to translate this idea from one form or reality to another. The artistic convention of the Mixed Reality author needs to use them to merge realities together.