Exploring the Adoption of Augmented and Virtual Reality in the Design of Customer Experiences: Proposal of a Conceptual Framework

Summary

This article explores the current and potential impact Augmented Reality and Virtual Reality have on Consumer markets by analyzing adoption patterns, different uses and specific applications in the commercial field.

The authors propose a conceptual framework from which the commercial implications linked to the introduction of high-impact technologies into the market will be analyzed. In developing this conceptual framework, it will cite and classify the key players by identifying the consumer industries in which a major disruption in consumer habits may be caused. The authors also review the relevance of technology-based marketing, emphasizing the main factors to be taken into consideration to evaluate its growth potential from the perspective of both the company and end users.

Augmented Reality and Virtual Reality can enrich consumers' perceptions of brands and transform business processes. Using these technologies makes it possible to bring the customer experience to a new level of convergence and immersion through close interaction between the real and the virtual world. When combined with other technological trends (ex. Internet of Things –IoT, Social Media, Wearables) it is possible to take consumers to a new sensory dimension (Immersive Media) and open a new era for creativity and innovation in strengthening the consumer-brand relationship.

This research project hopes to stimulate reflection on adoption patterns and technological factors to be taken into account in designing business strategies and in managing customer experiences based on Augmented Reality and Virtual Reality.

Key words: Marketing Strategy, Augmented Reality, Virtual Reality, Customer Experience, Innovation.

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1. **Introduction**

Augmented reality (AR) and Virtual Reality (VR) are the spearhead of a revolution in the digital communication ecosystem towards a truly immersive media. They can enrich consumers' perceptions of brands and have the potential to transform consumer experiences and business processes.

Many brands in different sectors are scrambling to figure out how they might try AR/VR in the market, as the technology is still in the early days. However, there are adoption barriers to take into consideration from the perspective of consumers and the company. Having a better understanding of the scope of these immersive platforms will be of aid in making the most out of these emerging communication channels.

This article explores the current and potential impact AR and VR have on consumer markets by analyzing the adoption patterns, different uses and specific applications in the commercial field.

In this first stage of this research, we will propose a historical and conceptual framework identifying the key players and consumer industries in which a major disruption in consumer habits may occur. We will review the relevance of technology-based marketing, emphasizing the main factors to evaluate its growth potential from the perspective of end consumers and companies.

2. Historical Evolution of Virtual and Augmented Reality

The origins of virtual and augmented reality can be found in the 1960s when photography director Morton Heilig created the first motorcycle simulator called the *Sensorama.* This simulator allowed users to experience a complete sensory immersion with images, sounds, smells, and vibrations (1962). Later came the theoretical work of computer scientist Ivan Sutherland, who suggested in 1965 that:

> « A display connected to a digital computer gives us a chance to gain familiarity with concepts not realizable in the physical world. *It is a looking glass into a mathematical wonderland ».*

This was the digital pioneer who, along with founder of the Department of Computational Sciences at the University of Utah, David C. Evans, created the virtual reality system called the *Head Mounted Display* (1966). This helmet-shaped device was the first to permit three-dimensional immersive visualization. However, in spite of Sutherland's best efforts to put his theories into practice, progress was stunted by the slow-developing digital ecosystem – computers at that time being too archaic to produce relevant results.

In the following years, drastic reduction in the size of computers and an increase in their calculating capacity sparked the growth of interesting projects, such as:

- The interactive system called ***Video Place*** (1975), created by the artist Myron Krueger.
- The ***Data Glove*** (1977), designed by Dan Sandin, Richard Sayre and Thomas Defanti, members of the Electronic Visualization Laboratory team at the University of Illinois.
- The first position sensors, like the ***Polhemus*** (1979), based on magnetic field technology.

Only years later, when computer scientists Jaron Lanier and Thomas G. Zimmerman founded VPL Research – considered the first company dedicated to commercially

producing virtual reality peripherals (specifically primitive versions of gloves and helmets in 1985 that garnered attention in popular media) – did the binomial "Virtual Reality" begin to enter the popular lexicon.

At the beginning of the 1990s, the gaming industry would fix its attention on this technology's potential with the arrival of W. Industries' *Virtuality* arcades (1991); and later, with the *Virtual Boy* console produced by Nintendo (1995).

At that time, an investigator at Boeing named Tom Caudell coined the term "*Augmented Reality*" to categorize improvements the company was making to its production processes. For these improvements, the company used software to display the wiring plans for finished pieces. Months after this term came into use, Steven Feiner, Blair MacIntyre, and Doree Seligmann developed the first prototype called Karma (1994).

All of these efforts had similar bottlenecks: lack of quality and speed of digital graphics, the need for expensive optics, nausea-inducing experiences and scarcity of easy paths to adoption were the major factors that caused this type of developments to go into a semi-dormant state until recently.

The two key developments that sparked the revived interest in AR/VR occurred in 2012:

1) On VR side (Oculus Rift): Developed by Palmer Luckey and eventually acquired by Facebook in 2014, the Oculus Rift demonstrated that the technical barrier that had previously frustrated creators had finally been overcome. Multiple companies have followed and created a thriving ecosystem (HTC, Sony, Samsung).

2) On AR side (Google Glass): Augmented reality glasses that have produced perhaps the biggest industry milestone to date – the first surgical operation (a Percutaneous Endoscopic Gastrostomy) carried out by American surgeon Rafael Grossmann using this Google device (2013). Although this product did not have all the expected commercial success, Microsoft followed through shortly after by announcing its Hololens headset and Magic Leap, which at the time of writing this article are still in development mode. These programs were launched and funded at an extremely high valuation point, adding an equally vibrant expectation for AR capabilities.

A most recent crucial development has been **Pokemon Go**. This game launched in 2016 in Australia, New Zealand, and the United States (July 6, 2016) became a massive worldwide sensation. Pokemon Go amassed more than 100 million downloads in just a few weeks. Nintendo's share price rose by an initial 10% by July 14 and it peaked at 50% on July 22. Nintendo gained ¥1.8 trillion ($17.6 billion) in market capitalization since the game's launch.

Pokémon Go (the idea of which originated from an April Fools' prank in 2014) combines the use of AR technology with the GPS and camera functions of various smart devices. This game's characters appear in augmented reality superimposed on the device's map, allowing players to capture them. There is an exploration element by having "Poké Stops" and "Gyms" tied to real-world locations. The sudden success of Pokémon Go illustrates the potential for Augmented Reality to become a game changing technology, with its ability to attract mass interest and engagement.

On the other hand, ***"Henry,"*** – an animated virtual reality experience available for the Oculus Rift platform and developed

by Oculus VR's film division, Story Studio – received an Emmy award in the Outstanding Original Interactive Program category (September 8, 2016). These awards were traditionally offered to major TV shows made by prestigious Studios. "Henry's" win marked the second year in a row that a VR Experience has won at the Emmys.

2. **Methodology**

For this stage of our research, we have focused on a literature review of articles, case studies, blogs and books related to virtual, augmented and diminished realities. We have also conducted several deep interviews with experts and executives in Mexico, Spain and the United States who are already applying these technologies (notably, Spain's New Horizons VR CEO Edgar Martin-Blas). Unfortunately, there is still a lack of a structured framework to guide Marketers and Academics in this new field. Our goal is to contribute with a conceptual framework to clarify constructs, adoption barriers and challenges to be assessed in future research projects.

3. **Conceptual Framework**

This conceptual framework encompasses three main blocks. The first part defines and compares three types of realities: Virtual, Augmented and Diminished. The second part clarifies the differences and interrelation between Mixed Reality and Immersive Media. Finally, the third and final part of this framework explores adoption barriers from two perspectives: The Consumer and the Company (brands).

Virtual Reality (VR)

Virtual Reality is a relevant area of study because it offers truly immersive experiences. VR is able to support creative storytellers with a completely new set of tools and capabilities, still in early stages of its full potential. Virtual Reality is a technology that allows for the creation of a new dimension in which it is possible to interact with any other person or object. This computer-generated environment makes the user feel as if they are physically in this virtual world by providing real time simulations and interactions using distinct auditory, visual, tactile, and olfactory sensory channels (Burdea, 1993).

Large industries, such as healthcare, media and entertainment, are showing great interest in VR, which in turn has driven the design of diverse platforms to build virtual landscapes that recreate everyday situations. Some examples would include making commercial transactions, simulating trips around the world, playing alone or with friends, or having virtual meetings or training sessions (Grimsdale, 1995).
Currently, there are two types of virtual reality: a) *Immersive Virtual Reality* and b) *Non-Immersive Virtual Reality.*

a) Immersive Virtual Reality (IVR): The user enters this digital, three-dimensional, stereoscopic, interactive environment via sophisticated hardware. This type of device is usually attached to the user's body, giving him or her the feeling that he/she is in a real environment in which he/she can walk around, fight, or reach objectives.

b) Non-Immersive Virtual Reality (NIVR): This is a synthetic environment featuring computer-generated images with the ability to create three-dimensional virtual spaces. The novelty is in the possibility of adding interactive objectives, videos, sounds, and even links with other virtual worlds. This is similar to what is offered by immersive virtual reality, but here the area is limited to a screen, which provides an experience of limited immersion.

Augmented Reality (AR)

This type of reality allows for the introduction of virtual elements in the real world through a technological development. AR is a combination of physical and intangible space giving users the ability to create beings, images, objects, or texts through a computer. In augmented reality, users can superimpose virtual elements onto the real world by providing additional relevant information to the environment he or she is actually seeing. This «*enriched*» or «*augmented*» environment is clearly advantageous in our current information and communication society.

To date, AR has already proven useful in various industries like entertainment, engineering, military defense, and of course, medicine (Azuma et al., 2001; Bimber & Raskar, 2004).

There are considerable differences between Virtual and Augmented Reality. One critical difference is the degree of immersion experienced by the user. VR surrounds the user completely in a virtual world, while augmented reality allows users to remain in the "real world." In sum, if virtual reality seeks to replace reality, augmented reality seeks to complement it.

Diminished Reality (DR)

In essence, diminished reality consists of the utilization of techniques taken from augmented reality, but with the opposite goal: where one adds elements to the real world, the other allows users to subtract or eliminate real objects (Azuma, 1997).

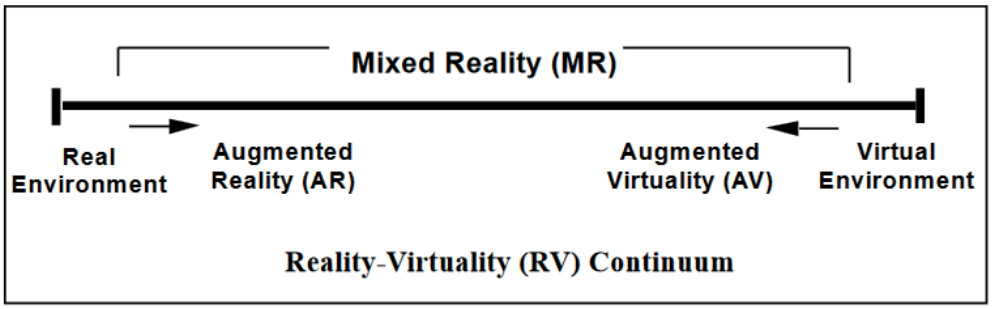
In 2001, Steve Mann (University of Toronto's Department of Electrical and Computer Engineering) proposed the concept of DR. Scientists Jan Herling and Wolfgang Broll (Ilmenau Technical University in Germany) took up this line of research and turned their focus to identifying and selecting objects in order to eliminate them. Some examples are:

- ***Hearing aids***: Reduce noise to make music sound clearer: for example, eliminating specific instruments or crowd noise during a concert.
- ***Touch-screen video cameras***: Extract objects in real time during filming.
- ***Security cameras***: Remove the images of people not under suspicion.
- ***Airplanes with clear floors***: Allow pilots to better see the runway, or applications that allow users to gaze at the stars or 360-degree landscapes as if walls and ceilings did not exist.

Mixed Reality and Immersive Media

Augmented Reality and Virtual Reality are distinct constructs, but are deeply interrelated: similar 3-D imaging techniques are applied, many of the technical and storytelling challenges are common, and both overlap in terms of the types of problem they can help to solve. When an AR experience shows a virtual object and it allows its exploration, it comes very close to being a VR experience. When VR headsets are equipped with cameras to "*pass-through*" real world images and overlay objects on them, they create experiences bordering those of an AR experience. Milgram and colleagues (1994) highlighted the interrelation of these constructs when they proposed the concept of a continuum between AR and VR. This continuum allowed the emergence of the term "*Mixed Reality*":

Figure 1: Simplified Representation of a AR/VR Continuum



Source: Milgram et al. (1994)

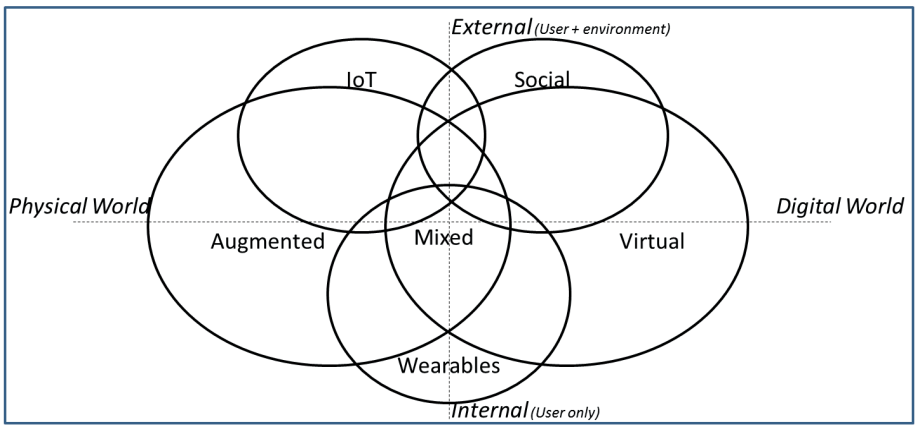
It is interesting to note that what seemed like separate worlds and techniques are indeed converging, and this convergence starts to be used in content creation under the notion of Immersive Media (Rose, 2015). Our proposed framework is therefore an expansion on the Mixed Reality notion, highlighting the fact that AR and VR are not alone in this mix anymore. Several new developments and techniques could be combined in order to achieve the phenomenon of immersive media. This type of media allows the user to immerse him/herself in a story from every possible perspective and sensorial dimension, interacting with both digital and real planes simultaneously. This interaction affects the inner experience sphere and the external environment elements.

Herein, we refer to technologies such as:

- ***Wearables***, that allow for two-sided communication with an individual's vitals
- ***Internet of Things (IoT)***, which enables interaction with real objects
- ***Social media***, which breaks the isolation of a single person experiencing this media.

Each of these elements expands into the continuum seen above, and adds the possibility of engaging with real and digital environments. The growing capability to combine these techniques is what allows the development of alternate worlds that are so appealing to consumers and brands.

Figure 2: Macro-Concept of Immersive Media



VR and AR Adoption Barriers

It is important to note that AR/VR may not fit every business. A well-considered AR/VR experience can be a transformative experience for customers, and may set companies on the way to profit from this platform as it continues to grow (Riley, 2016). A case-by-case analysis reveals diverse purpose-driven situations. Let us look at some of the main barriers preventing a more widespread proliferation.

AR/VR Adoption Barriers: The Consumer Perspective

Price: The total expenditure needed to achieve a decent experience must be within reach for average consumer. Nowadays, the necessary expenditure can reach the $750-2,000 USD range. The exact target price point varies in each country. A key factor helping to break this barrier is that "entry-level" experiences can be achieved with an already existing device: smartphones. This means that for those users who own a high-end phone, the only barrier is acquiring the headset.

The sharing economy has proven to be an effective way to reduce what otherwise would be significant spend/investment barriers for everyday users (e.g. Uber for car ownership). There could be an opportunity for such disruption to occur in the AR/VR space as well, although this research yielded no known example.

Device Comfort: The Device must not be cumbersome, painful or otherwise uncomfortable to wear for long periods of time. In the case of VR, the main variable still affecting this is the weight of the Head-Mounted Display (HMD). Currently, these headsets can weigh as much as 500-600gr, which can cause fatigue and injury if not used properly.

In the case of AR, the field of view (FOV) is the main limiting factor. AR HMDs available today are reaching FOVs of 40-60 degrees; technology must evolve to achieve FOV values close to their VR counterparts (~90-110 degrees)

For both, VR/AG, high-medium definition screen resolution is still a problem, as artifacts in the image (e.g. visible pixel borders) can break the VR/AR illusion. Nowadays this quantity can reach 1080p per eye, and probably needs to grow to 4K.

Aesthetics: One undesired effect of one of the pioneers in the new wave, Google Glass, was the rejection of the device among certain segments due to the way its users looked and behaved. This is called the "***Glasshole effect***", and the risk of rejection is still something that must be addressed to see growth, particularly for AR applications. Currently, devices have very limited aesthetics customizations (if at all). Improvements in this direction will make it possible to combine AR/VR equipment with personal style.

Quality of Experience: Preventing nausea is necessary for both types of experiences, but represents a greater challenge in the VR side. For VR experiences even the most advanced devices still require wired tethering, which affects the quality of the exploration experience and is related to the length of the cable. This can also cause some discomfort. Development of untethered or wireless-tethered experiences will represent significant progress in making experiences better.

In this nascent industry, many **User Interface** (UI) and **User Experience** (UX) elements still need to be optimized, with most of the experiences taking inherited elements from previous platforms (PC, Smartphone). However, this new medium can greatly benefit from new UI/

UX paradigms supported by novel user input interfaces such as: *gaze-tracking*, *advanced haptic,* and specifically, *hand gestures*. The growing maturity of these techniques will increase the immersion gap with other types of media.

Content Availability: Any platform is useless without content. In the case of AR/VR, supply of this content remains a challenge. In general, when companies both in entertainment and non- entertainment industries implement VR/AR experiences as part of their business models, this barrier will start to become less relevant. In VR, one factor helping to alleviate this is the growing availability of consumer-grade 360° cameras to feed User-Generated Content (UGC) communities.
Monetization of this Content is an open question in this regard as well. Currently, there is a divide between thinking of AR/VR as extremely premium content (and thus subject to strong monetization) and making the purchase of AR/VR equipment something attractive (which asks for substantial free content to enjoy the experience).

AR/VR Adoption Barriers: The Company Perspective

Strategic Alignment: Many companies in several consumer and industrial sectors are experimenting with AR/VR just for the sake of experimenting. Experimentation is not enough. This could lead to abandonment unless companies actively work on finding applications that fit and reinforce their overall business and marketing strategy. A way of doing this is to think of paradigm-breaking use cases where AR/VR can speed-up processes or remove obstacles in every day work. It can also aid in strategic decision-making due to its ability to immerse, enrich and combine rich visualization with interaction.

Addressable Market: Depending on the shape of consumer perspective, companies that are aware of the developments in AR/VR should also grow their understanding of emerging user segments. These segments, and their relationship with the company's own customer segmentation strategy, must be understood to show a clear picture of which will be the most relevant platforms/media. It is in these platforms where relevant customers could be reached.

Talent Pool: The skillset needed to produce AR/VR content is unique: 3-D, video, interaction design, mobile, storytelling, etc. This combination of technical and non-technical skills is proving difficult to acquire. On the other hand, it is also a skillset that might not fit well with the overall company's profile (depending heavily on industry), which would in turn become a retention problem. This translates into a reduced and niche Talent Pool.

Companies have several options in addressing the lack of talent. In the following, we propose three non-exclusive options:

a) ***Association with Specialized Players***: Let early niche companies be the source and filter of talent and let them have a stronger role in the experience lifecycle.

b) ***Organic Growth***: Develop the talent in-house with existing resources.

c) ***Partnership with Universities***: Identify the skills gap to try to develop targeted programs aimed at developing such skills.

Key Performance Indicators (KPIs): Being able to establish concrete KPIs linking AR/VR activities with productivity gains, communication improvements,

sales growth and other business objectives will help in justifying providing funding for more ambitious AR/VR projects. As technologies mature, some components are likely to reach lower price points throughout the entire value chain. This will help in reducing the investment barrier and shortening the payback periods of project involving AR/VR content. This is partially a hardware and equipment availability issue and partly a problem of professional services cost.

Market Fragmentation: In the current growth phase of AR/VR, the trend is for continuous emergence of new platforms. This creates a significant issue for content creators, as incompatibility between these platforms is a barrier to achieve cost-effective reach. Being able to reach a desired number of users without having to re-develop content will make content in AR/VR easier to become financially viable. This could be done either by creating or adopting open standards to secure interoperability between the platforms, or simply by industry player consolidation once technology enters a more mature phases of development.

4. Discussion: Challenges and Market Opportunities

Virtual, augmented, and diminished reality technology have attracted attention from big tech players like Facebook, Google, Apple, Microsoft, Sony, HTC, Samsung, Intel, Xiaomi, and Amazon, which have announced their short and medium term projects. In the future, several of these companies may have a clash of interest in their quest to grow this new ecosystem.

According to Goldman Sachs, virtual and augmented reality will generate hardware sales in the amount for $80 billion USD (€71 million) in 2025, a sum currently generated by personal computer sales. Gartner estimates that by 2020, around 40 million pairs of virtual reality glasses will be sold around the world, increasing the number of VR/AR/DR projects.

Table 1 shows some examples of successful AR/VR initiatives already implemented by brands/companies in different areas.

Table 1: Examples of Successful AR/VR Applications

AR Applications	*VR Applications*
Sales: *"Show in my home" by IKEA* Uses AR to simulate how an item would look in an existing environment.	***Entertainment:*** *Long form Cinema by Fox The Martian VR Experience* Studio-grade content with carefully crafted narratives for VR viewing.
Sales: *Magic Mirror by Uniqlo and Magic Mirror Inc* Combines AR and gesture interfaces to provide item information to customers in a mirror, and simulates how an item would look on a person.	***Entertainment****: Live events streaming by Fox NCAA Basketball, US presidential debates VR streaming, Rhapsody VR's live 360°concerts* Has live content streamed in 360°. Primarily sports, but also concerts, speeches, etc.
Medicine: *Anatomy highlighting for error reduction by Accu Vein* Enhances a doctor/nurse's vision with overlays of relevant body parts to aid in execution of specific medical procedures.	***Training:*** *Simulators by CAE training and Seabery* Combines visualization and gesture interfaces to simulate real work environments.
Automotive*: Assisted driving by Jaguar* AR / holographic to display navigation, warnings, road safety highlights, etc.	***Culture/ Education****:* *VR tailored courses by zSpace* Crafts educational content taking advantage of new visualization and experiences from VR and AR.
Operations*: Overlaid instructions sent to workers to complete complex construction/assembly jobs.* ScopeAR is a software layer enabling this across several devices (ie. Daqri, ODG…)	***Analytics:*** *VR dashboards Use the 3-D space as information visualization tool (ie.. carting, correlating).* Applies to both general information visualization and in VR-specific analytics (ie. interaction/visualization heatmaps). Demonstrated by CognitiveVR.

The use of portable (*wearable*) technology incorporating virtual, augmented, and diminished reality will considerably enrich our daily lives. Tasks like reading a product's instructions, or problems related to language barriers will cease to exist or at the very least, to be diminished.

Among the sectors that will receive a tremendous boost will surely be Education. These technologies also have the potential to revolutionize Advertising, Marketing and Entertainment by taking sensory experiences to a new level of immersion. There are also great opportunities for the proliferation of these innovations in the Healthcare sector.

The greatest obstacles or barriers for the adoption and diffusion of these tools are associated with consumer education, cultural change, and innovation acceptance. Technical / Technological difficulties and adoption barriers related to cost are temporary (Grossmann, 2015).

Table 2 summarizes the AR and VR adoption barriers for consumers and companies analyzed in the conceptual framework. Removing these barriers will require changes to foster their adoption and diffusion worldwide.

Table 2: AR/VR Adoption Barriers for Consumers and Companies

AR and VR Adoption Barriers	
CONSUMER	***COMPANY***
Price	*Strategic Alignment*
Device Comfort	*Addressable Market*
Aesthetics	*Talent Pool*
Quality of Experience	*Key Performance Indicators*
Content Availability	*Market Fragmentation*

We predict that innovations in altered realities will be rapidly adopted because they have the potential to cause disruption in various categories. However, large-scale implementation will require strong investment on the part of individuals and institutions. This implies the risk of creating an access gap among different socio-economical segments and countries.

5. **Future Research and Limitations**

This paper presents a conceptual framework built from an extensive literature review, interviews and case study analysis meant to clarify concepts and challenges associated with alternative consumer realities (VR/AR/DR). Our goal was to stimulate reflection on adoption patterns and technological factors to be considered in the design of business and branding strategies, as well as the management of customer experiences based on virtual, augmented and diminished realities in different sectors and categories. In the following phases of this research project, we plan to apply quantitative techniques to assess the adoption patterns of these innovative immersive tools using the Technology Adoption Model (TAM) to enrich the study of adoption patterns and barriers with quantitative thresholds. Our focus will be in two main sectors: Entertainment and Healthcare.

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