

A MARKET STUDY ON IMMERSIVE TECHNOLOGIES IN INDIA: PROPELLING THE AVGC SECTOR





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Esya Centre

B-40 First Floor
Soami Nagar South,
New Delhi - 110017, India

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Authors:

Vani Tripathi Tikoo, a Creative Professional, Actor, Producer and Member of the Central Board of Film Certification;
Akshat Agrawal, Technology Policy Expert;
Varun Kakar, Emerging Technology Enthusiast;
Mohit Chawdhry, Fellow, Esya Centre, and;
Vaishnavi Prasad, Research Assistant, Esya Centre

Cover Illustration: Taniya O'Connor

Layout & Design: Khalid Jaleel

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EXECUTIVE SUMMARY

India's media and entertainment (M&E) industry is set to be an engine of growth for the country's economy. Within the industry, the animation, visual effects, gaming, and comics (AVGC) sector shows immense promise and is likely to grow at a CAGR of more than 35 % over the next five years. The increasing adoption of immersive technologies, like Augmented and Virtual Reality, will be the principal drivers of this growth. The total market size of AR/VR in India is expected to advance at a CAGR of 38.29 % to \$14.07 billion by 2027, according to Research and Markets. In this report the Esya Centre explores how immersive technologies will change the way creators produce content and audiences consume it. The report also assesses the readiness and competitiveness of India's AR/VR industry and suggests some policy measures that could further bolster the sector based on insights from semi-structured interviews with relevant stakeholders in the AR/VR ecosystem.

Technology Overview

- AR adds an additional layer of graphics and visuals to a user's surroundings, to make real-world settings interactive. On the other hand, VR relies on creating virtual immersive environments that users interact with using specialized devices, such as headsets and handheld controllers.
- Immersive technologies will change the way content is consumed. Most experts reckoned that AR/VR will eventually replace screens, and make content consumption seamless.
- The production of games, movies, and other content will also change significantly as virtual production techniques, which rely on immersive technologies, become more commonplace.
- Consumers will adopt AR early and widely because of the ease with which it can be rendered on mobile devices. As a result, it is likely that AR-based content and games will flourish in India. Comparatively, VR adoption will be slower and will depend on headsets becoming more accessible and easier to use. In the long term, the market for VR-based content is likely to be larger than for AR.

The Indian AR/VR Supply Chain

- The AR/VR supply chain includes four distinct segments: infrastructure, hardware, software, and content.
- India is well positioned on the infrastructure layer because the cost of data in the country is one of the lowest in the world. Therefore, mobile internet is increasingly accessible to large segments of the population. As of 2021, India had 1.2 billion mobile phone subscribers, of which 750 million were smartphone users. Mobile penetration is set to cross the 100 % mark in 2023, driven by the increased availability of devices and connectivity to Tier 2 and Tier 3 cities and villages
- The mass adoption of AR and VR will hinge on the success of India's 5G roll-out, which began in September 2022. There is also a robust market for cloud services, which will be used to render content remotely before streaming it to a user's device. Revenue from the Indian public cloud services market was estimated at \$4.6 billion for 2021 and is expected to grow at a CAGR of 24% to reach \$13.5 billion by 2026.¹ The cloud services market is dominated by large foreign players and domestic firms. A survey of Indian Chief Information Officers (CIOs) reveals that Amazon Web Services, Microsoft Azure, and Cloud4C are the most preferred cloud service providers.²
- On the hardware front, India's prospects are mixed. There is likely to be a sizeable domestic market for VR devices in the future. But their manufacturing will take place in the US, China, and South Korea. However, Indian manufacturers may have an advantage when it comes to creating cost-effective headsets and devices that cater specifically to Indian requirements, especially in towns and villages.
- Hardware manufacturers, based in the US and China, dominate the creation of platforms/operating systems that power devices. India's role in developing these platforms will hinge on the approach that the larger ecosystem adopts. A walled garden attitude, which centers around closed ecosystems such as Apple's iOS, would mean that the country's talent will be involved in content creation while device manufacturer develop platforms. Conversely, an open-source approach could favour the country's developer ecosystem, because of its ability to scale up existing ideas and products.
- The advent of games, animations, and VFX for immersive experiences is an area of strength for India because a skilled workforce and a market for local content exist in the country. With appropriate policy support, India could become a global hub for AR/VR content.

Human Resource

- Human resources and talent are also abundant in India. The country is the preferred destination to outsource IT and BPO-related work due to its English-speaking workforce. Moreover, animation and VFX studios based abroad are also outsourcing work to creative talent in India. This expertise is likely to augur well for the AR/VR ecosystem.
- However, industry readiness and the employability of fresh graduates are major concerns. Outdated curricula, lack of devices to train on, and an absence of skilled trainers mean that pedagogy and training are theoretical. Moreover, top creators and developers often choose to work for foreign companies that invest significant amounts in research, development and talent retention.

The Path Forward

- India is well positioned to be a leader in immersive technology development due to its expertise in IT, skilled workforce, and a large domestic market. However, the realisation of this potential will depend on timely and relevant policy interventions.
- Experts said that the treatment of AR/VR companies, under laws like the Customs Act and the Goods and Services Act, must be made clear. This sharpness is vital to the ease of doing business. They added that streamlining access to finance, particularly from abroad, would bolster the risk-taking ability of these companies.
- Experts also said a collaborative approach between the public and private sectors could promote innovation. Hackathons, incubators, and grants and scholarships that cater to immersive technology innovation, are some initiatives that can help power the sector.
- Another area that requires policy interventions is skilling. A stakeholder observed that only five percent of Indian engineers are employable and an additional 50 % requires serious upskilling and enhanced education. A survey by Scaler, an ed-tech startup, reported that of 15 lakh engineers who graduate from India every year, only 2.5 lakh obtain jobs in relevant technical domains.³
- The Government must update curricula in high schools and colleges, to reflect developments in immersive technologies. Moreover, opportunities in

animation and design must also be played up. At the same time, skilling must respond to the needs of the private sector, because that is where most graduates and students will be employed.

INTRODUCTION

The Indian media and entertainment sector has witnessed rapid growth after globalisation and economic liberalisation, particularly due to increased access to mobile devices and the internet. With the world's second largest online population,⁴ India is set to be a key market for newer forms of content and entertainment. It is already one of the largest content consumers online, and has the largest number of YouTube users in the world with the United States being a distant second.⁵ Given these factors, media and entertainment is considered a sunrise sector in India, expected to contribute significantly to economic development and employment generation in the next decade. Within the larger industry, the animation, visual effects, gaming and comics (AVGC) sector shows the highest growth rate at about 29% CAGR.⁶ If this rapid growth continues the sector may emerge as the backbone of India's media and entertainment industry, and capture a significant chunk of the global market, where it currently accounts for less than 1% of the total.

In recognition of the sector's immense potential, the Ministry of Information and Broadcasting constituted the Animation, Visual Effects, Gaming and Comics (AVGC) Promotion Taskforce in April 2022.⁷ The task force was mandated to study and provide recommendations on creating a national AVGC policy with a specific focus on skill development, employment opportunities, and foreign investment.ⁱ In assessing the sector's growth potential, attention must be paid to the manner in which immersive technologies, namely augmented reality (AR) and virtual reality (VR), will revolutionise the production and consumption of animation, VFX, and games. As its name suggests, AR overlays the user's surroundings with information using cameras and other sensors. VR on the other hand creates completely

i. The Terms of Reference of the Task Force include the following:

- (a) Framing of a national AVGC policy,
- (b) Recommend national curriculum framework for Graduation, Post-Graduation and Doctoral courses in AVGC related sectors,
- (c) Facilitate skilling initiatives in collaboration with academic institutions, vocational training centers & Industry,
- (d) Boost employment opportunities,
- (e) Facilitate promotion and market development activities to extend global reach of Indian AVGC Industry,
- (f) Enhance exports and recommend incentives to attract FDI in AVGC sector.

immersive and virtual worlds that users can explore using headsets and other sensory controllers. The increased adoption of immersive technologies in the AVGC sector can bolster the quality of content and the efficiency and scale at which it is created.

Given the above, it is important to understand the likely impact of immersive technologies on the broader AVGC sector in India, and whether the country can produce devices, content, and software for AR and VR. The report explains how immersive technologies work and their transformative potential for content consumption and production. It gives an overview of the supply chain involved in creating immersive content, and identifies the areas where India has an advantage or disadvantage. Lastly it assesses the country's capacity to make immersive content from a human resource standpoint. The report also provides valuable insights for policymakers and stakeholders considering how best to harness the sector's immense potential.

Methodology and Structure

The report relies on primary and secondary forms of research. The primary research was in the form of 10 interviews with industry experts from animation and gaming studios, XR development labs, and venture capital firms. The interviews were semi-structured and relied on discussion guides featuring 10-15 questions per interview. The interview transcripts were analysed to draw insights and map common trends. Findings from the interviews are captured in anonymised form throughout the report. The quotes have been edited for readability. The secondary sources of information include industry reports, market studies, academic papers and news reports.

The report is divided into four sections. The first provides an overview of AR and VR technologies and their use in the AVGC sector. The segments of the AR/VR supply chain, namely infrastructure, hardware and software are examined in the second section, and key trends that will influence the adoption of these technologies in India are identified. The third section provides an overview of the human resource landscape for AR/VR in India. It identifies the skilling and education related measures that may be adopted, and the final section summarises the key findings of the report.

1. THE NEXT STEP IN ENTERTAINMENT

Modern entertainment industries can be viewed through the lens of ever evolving media. From the first radio shows to online podcasts or the first silent films to the bevy of customisable video-on-demand services available today, it has been a joint march of technology and the creative arts. Technological developments create new possibilities, requiring updated skill sets, infrastructure and responses, and making the entertainment ecosystem richer and more complex in response to growing consumer demands. A major recent development in this process is what has come to be known as ‘extended reality’, made possible by AR and VR technologies, which can create immersive, interactive experiences radically different from the current forms of content consumption. This section explains how the technologies work and their likely impact on media consumption and production.

Augmented reality

AR superimposes virtual objects or environments over real images or environments, adding an interactive layer to (or augmenting) reality. Perhaps the best known use of this technology is in the mobile game Pokémon Go, which asks users to ‘catch’ the eponymous Pokémon in real life locations, and has been downloaded over a billion times since its release.⁸

AR relies on hardware already in widespread use, mainly tablets and smartphones, making it a mobile friendly technology that has seen deployment across healthcare, retail, education and entertainment.⁹ In addition to entirely AR-based experiences, AR technology also has applications that supplement existing media products, such as by providing additional information and experiences around video content,¹⁰ integrating fan experiences at physical sports venues,¹¹ and providing extra features, artwork and bonus content for music albums.¹² The majority of experts agreed that AR’s large number of use cases and relatively simple deployment will see it gain mass adoption before virtual reality, which is currently limited to a handful of uses.

Virtual reality

VR creates fully inhabitable and immersive virtual environments, usually with the help of specialised hardware such as headsets and motion-controlled input technologies. These give the user the feeling of complete immersion in an interactive environment, a scenario developed further in the Steven Spielberg film *Ready Player One* (2018), where the user is separated from their surroundings by replacing their normal field of vision with linear content or a fully immersive 3D environment. VR's immersive capabilities were underscored by the Covid-19 pandemic,¹³ where it allowed users to transport themselves into different environments in the comfort of their homes. Notably, several museums around the world created VR tours during this time, letting users 'visit' and enjoy the exhibits through their VR headsets.¹⁴

With a global movement towards AR/VR adoption, we can expect implementation to improve, the hardware to become cheaper and more portable, and the experience to become more immersive – whether it's a blended experience of digital objects and graphics with the physical world or an entirely virtual experience beyond the physical world. Currently, both AR and VR are largely restricted to the device screen. The biggest jump we can expect in future will be the blurring of boundaries between the screen and the physical world itself. Several experts noted that as immersive technology improves, screens as a medium for viewing content will disappear. One expert explained:

“I see all the screens going away. They will vanish from use. We will be wearing devices on our eyes, just like spectacles. So most of the consumption will go on these wearable devices. It could be your wristwatches or your eyeglasses etc.”

There will likely also be greater overlap between AR & VR. The industry has started using terms such as mixed reality (MR) and extended reality (XR) to refer to these overlaps in technologies. A useful way to think this space is in the umbrella category of 'immersive technologies', with AR/VR being a component technology under the umbrella.

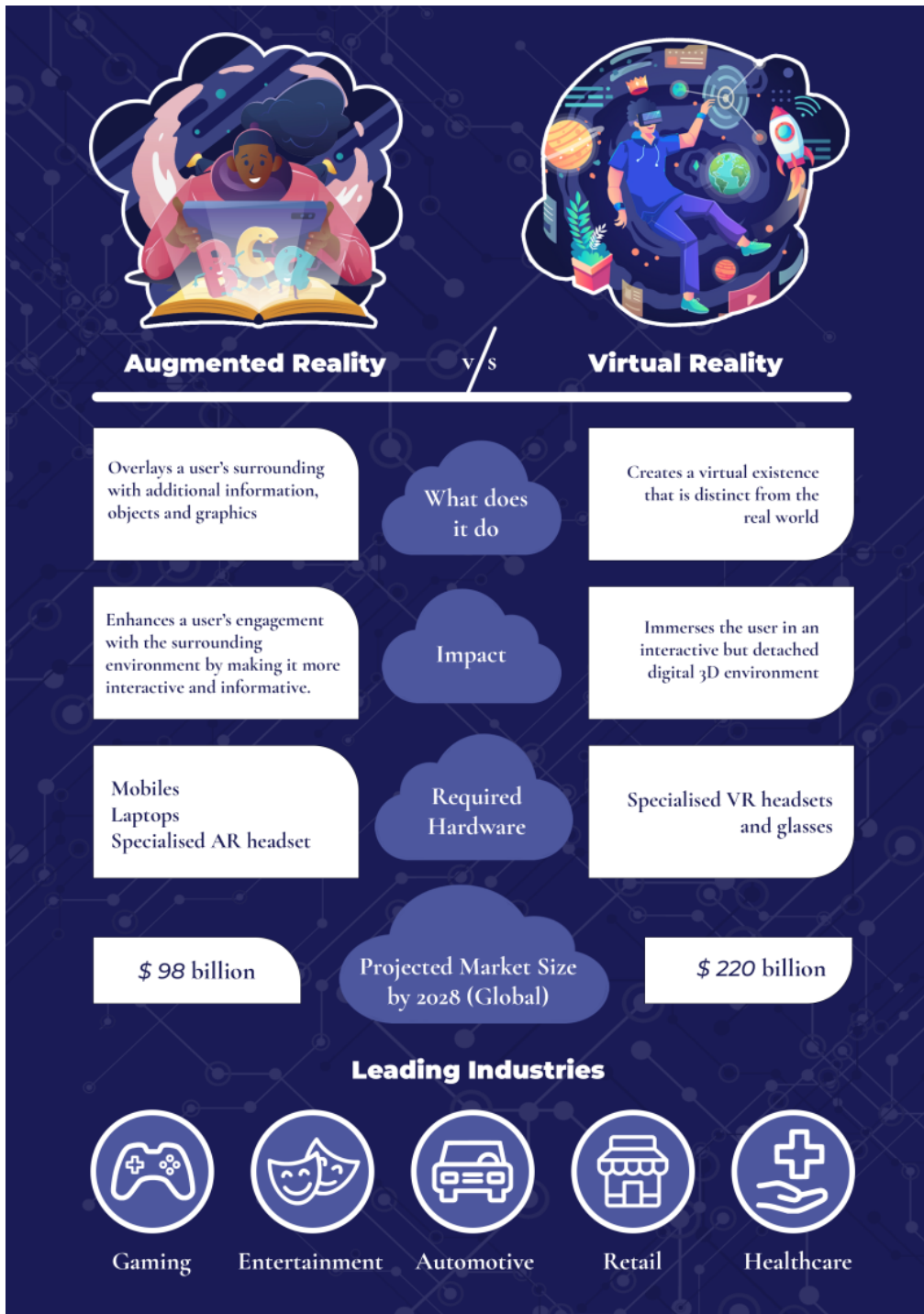


Image 1: An overview of AR and VR technologies

Impact on content consumption

Immersive technologies may become game changers in the consumption and production of content. AR/VR technologies allow consumers to view content from multiple perspectives: for instance, watching a football game from different vantage points. VR in particular lets users conjure up a screen wherever they desire, and as the hardware becomes increasingly compact, fully immersive and portable experiences will become more viable. Unlike current forms of content consumption, the user's entire focus and attention will be directed to the content in question. As an expert noted, *"for the first time you get a hundred percent focus only on that piece of content in front of you and nothing else, which is great."* Creating interactive and immersive virtual environments is particularly useful in gaming. Indeed, the gaming sector has been at the forefront of technological breakthroughs and innovation in the VR space. Many international game titles, such as *The Elder Scrolls V: Skyrim VR* and the upcoming *Horizon Call of the Mountain*, are getting VR spinoffs. These give users the sensation of being immersed in the game world, giving them a first-person perspective of an entirely virtual environment that they can interact with via motion controls and sensors in the headset.

Another key characteristic of the extended reality consumption experience is the chance to take the community and social aspect of the experience from the device back into the physical world. The game *Pokémon Go* by Niantic Studios was recalled by one of our interviewees as one of the best examples of a newer title taking advantage of extended reality mediums. The game achieves this by using geolocation to link digital events with real-world locations in the form of collectibles and territory control mechanics, allowing users to experience a shared Pokémon world superimposed over reality.



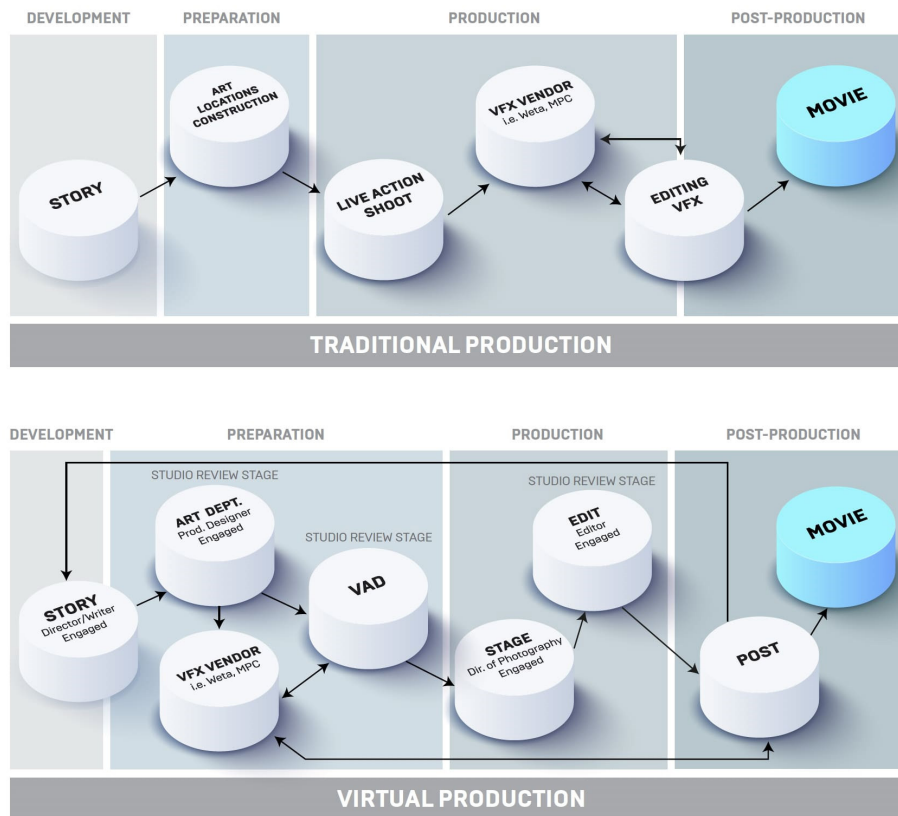
Image 2: A snapshot of Pokémon Go's AR utilisation (Source: Niantic)

Hence, immersive technologies are likely to change the manner and form in which users consume content. However, the content itself is not expected to be very different. **Instead of thinking of these technologies as replacing traditional content, stakeholders viewed them as an added layer on top of existing linear content. One predicted these technologies would become integrated into traditional content products to provide additional value to consumers. The popularity of these ‘new’ ways of interacting with content over traditional ways remains to be seen. Some genres will lean towards greater immersion, while others may continue to be enjoyed as traditional linear content.**

Streamlining production and content flows

While immersive technologies will significantly alter how content is consumed, they may have more significant effects on its production. Both technologies, particularly VR, play an important role in enabling virtual content production. Virtual production brings techniques from game design into film, allowing post-production processes such as rendering computer-generated images to be performed at the pre-production stage. This resolves a major problem with traditional production flows, where the process is linear and non-iterative. Cinematographers and directors must plan and capture scenes, which are then embellished with visual effects and digital objects post production. As a result, errors or shortcomings at the initial stages can lead to significant expenses post production, even requiring reshoots.

Virtual production techniques, such as in-camera VFX, allow technicians to see what the CGI assets will look like before shooting the scene with actors. The greater scope of creative iteration from the relevant teams and the ability to give technicians an idea of what the final shot will look like in the pre-production phase should result in clearer communication between teams, greater efficiency and reduced set time, saving costs.



Traditional vs. Virtual Production for Film

Visual development by Fox VFX Lab

Image 3: Differences in traditional and virtual production flows (Source: Fox VFX Lab)

Although capital-intensive to set up, virtual production pipelines have widespread impacts on locale- or period-based content endeavours. The set can be recreated virtually during the production and pre-production stages. High fidelity 3D assets based on real-world structures, people and objects are also easily recreated using photogrammetry and point clouds. This can be a boon especially for lower-budget productions, letting them create a more polished final product with production values closer to the blockbusters. While these techniques have been in use in game development and film production for some years now, the growing adoption of AR/VR will democratise virtual production, making it accessible to a larger cohort of content producers and creators. In time such techniques may also benefit independent creators, such as social media influencers, by enriching the quality of their content.

High quality facial recognition and motion capture will also benefit from increased AR/VR adoption. These technologies make complex animations seem fluid, believable and seamless to viewers, but required expensive hardware and a high standard of technical ability to execute.¹⁵ The emergence

of immersive technologies has led to rapid innovation in this space and a drop in prices and technical barriers to entry. An example of this technological democratisation is Apple's AR Kit, which allows quality facial animation capture on recent iPhone and iPad Pro models and can easily be integrated into existing virtual production pipelines.

Overall, the development of AR/VR technologies will significantly bolster the ability to produce content in virtual environments, improving the realism and fidelity of animations and VFX in games, movies and on-demand shows.

2. AR/VR SUPPLY CHAIN DECONSTRUCTION

AR/VR adoption has grown across sectors in India, including AVGC, health, manufacturing and retail. The sector grew from USD 0.34 billion in 2017 to 1.83 billion in 2020 at a CAGR of 75%.¹⁶ According to Research and Markets, the total market size of AR/VR in India is expected to advance at a CAGR of 38.29% to USD 14.07 billion by 2027. This section seeks to understand the factors likely to fuel this explosive growth. It identifies the key drivers of adoption and outlines the segments of the AR/VR supply chain, namely infrastructure, hardware, software and content. It also identifies the important players in each segment and evaluates the role that Indian enterprises are expected to play.

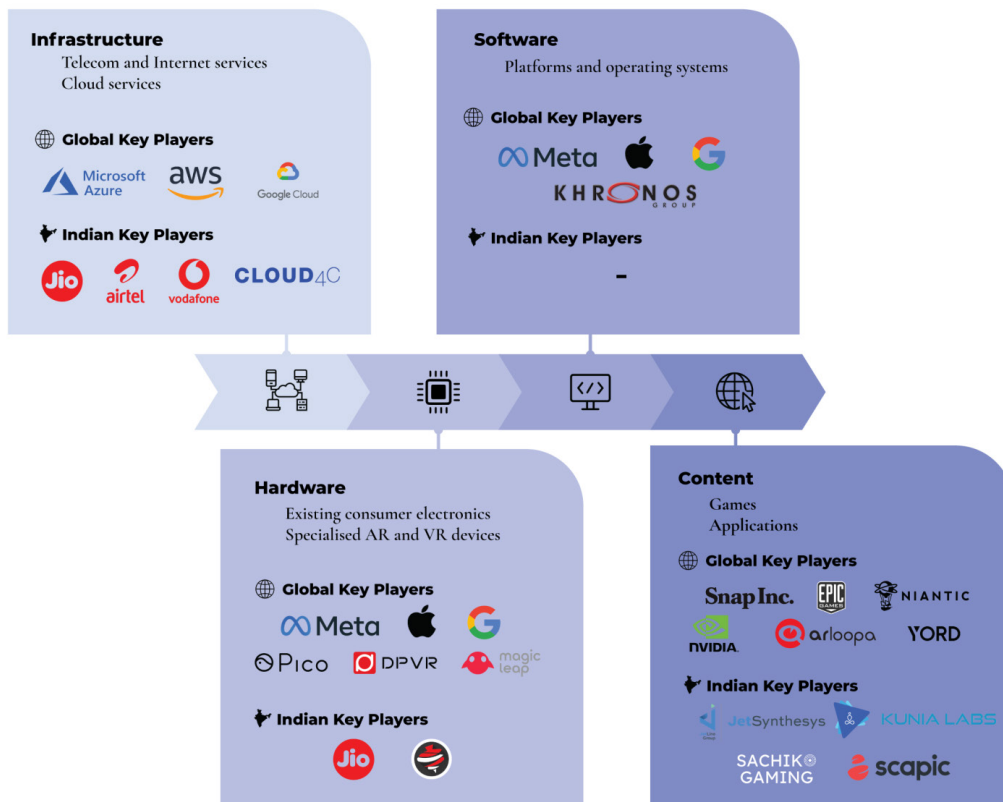


Figure 1: An overview of the immersive technology supply chain (Source: Author compilation)

Infrastructure

Telecom and Internet Services

Network infrastructure forms the bedrock of most digital technologies, and immersive technologies are no different. The medium for content delivery, whether immersive gaming or animation, is predominantly the internet. Hence, entities involved in providing network connectivity will play an important role in the growth of immersive technologies. These technologies involve the real-time rendering of 3D objects in high definition, requiring fast connection speeds, low-latency connections, and expansive network coverage.¹⁷

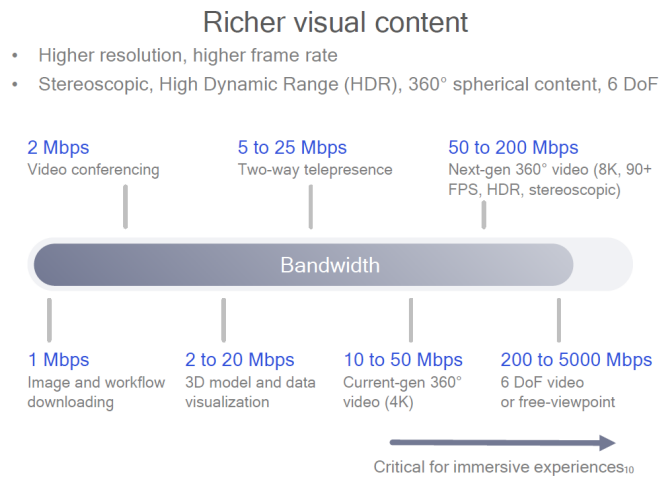


Image 4: The importance of high bandwidth for immersive experiences (Source: Qualcomm)

Given these requirements, most experts agreed that the deployment of 5G networks by telecom service providers would be a critical enabler for the adoption of immersive technologies. 5G is the next generation of mobile connectivity and promises higher bandwidth, lower latency, and increased coverage area, all of which are crucial for immersive experiences. A stakeholder explained the link between 5G and immersive technologies as follows:

“Right now, whenever you log into a website, there are certain 2D images that load in five seconds to ten seconds. If the website has very heavy images or if it’s cloud based, then ten to fifteen seconds. But that won’t be the same case with 3D images. What we are doing is trying to compress the 3D content as much as possible. But still,

that compressed 3D image would take three minutes to load for a simple, basic experience. As a result, you cannot develop a product that includes these features. But with 5G bandwidth, this problem is solved. We can easily utilise higher-sized rendering and 3D images in our application and sites”

While increased 5G connectivity will boost the adoption of immersive technologies, especially AR, realising truly persistent and immersive experiences will need the widespread deployment of mmWave or high-band 5G, which supports ultrafast, low latency connections. Broadly, 5G operates across three spectrum bands: low, mid and high. The low band (<1GHz) enables coverage of larger areas but offers only incremental improvements in speed and latency. The mid-band spectrum (1–6 GHz) provides much faster speeds than 4G and extends across wide areas, suiting it to deliver fairly immersive experiences to users. But truly fast speeds, of over 2Gbps, can only be realised on the high band spectrum, also known as mmWave 5G (24–300 GHz). However, mmWave 5G has a range of only a few kilometers, requiring the installation of antennas at short distances from each other.¹⁸

The deployment of 5G in India has already begun. The two major telecom service providers, Reliance Jio and Airtel, have initiated 5G services for users in select cities.¹⁹ Vodafone India also acquired spectrum for a 5G rollout during the recent spectrum auction.²⁰ The Government has also allotted spectrum to BSNL, a public sector undertaking that provides telecom and internet services. Both are expected to offer 5G services within the next year,²¹ and statements from the TSPs suggest that 5G services will be available across India by 2024/25.²² If the tariffs for 5G are not significantly higher than existing 4G offerings, many Indians could have access to 5G services in the coming decade.

While the TSPs mentioned above have acquired spectrum in the mmWave (26GHz) frequency, it appears this band will most likely be used for enterprise uses and captive connections, while the low and middle bands will be used for retail consumers. Hence, we can expect noticeable but not drastic improvements in latency and speed in the coming years, which should allow for improved immersive experiences.

Cloud Services

Besides fast networks, rendering immersive experiences especially in VR requires considerable computational power. Currently this power is drawn from the device delivering the immersive experience. The devices used for

delivering immersive experiences to users include smartphones, laptops and PCs as well as specialised hardware such as AR glasses and VR headsets. However, their computational power limits the quality and depth of the immersive experience, and non-flagship mobile phones and laptops can only deliver basic AR and VR experiences. While dedicated headsets deliver a better experience, they are too bulky to use for long periods. As a result, most experts think the computational and processing aspect of delivering AR/VR experiences, especially for gaming, will shift to the cloud. This means that the game or application code will be rendered using a cloud service provider’s infrastructure, and the product will be streamed seamlessly to the user device. This will let consumers experience high fidelity and realistic XR experiences without investing in expensive equipment. Major companies in the gaming market have launched cloud gaming services, such as Microsoft (Project xCloud), Sony (PlayStation Now), and Nvidia (GeForce Now).

India is among the fastest growing markets for cloud adoption worldwide. Revenue from the Indian public cloud services market was estimated at USD 4.6 billion for 2021 and is expected to grow at 24% CAGR to reach USD 13.5 billion by 2026.²³ The cloud services market is dominated by large foreign players and by domestic firms – a survey of Indian CIOs reveals that Amazon Web Services, Microsoft Azure and Cloud4C are the most preferred cloud service providers.²⁴

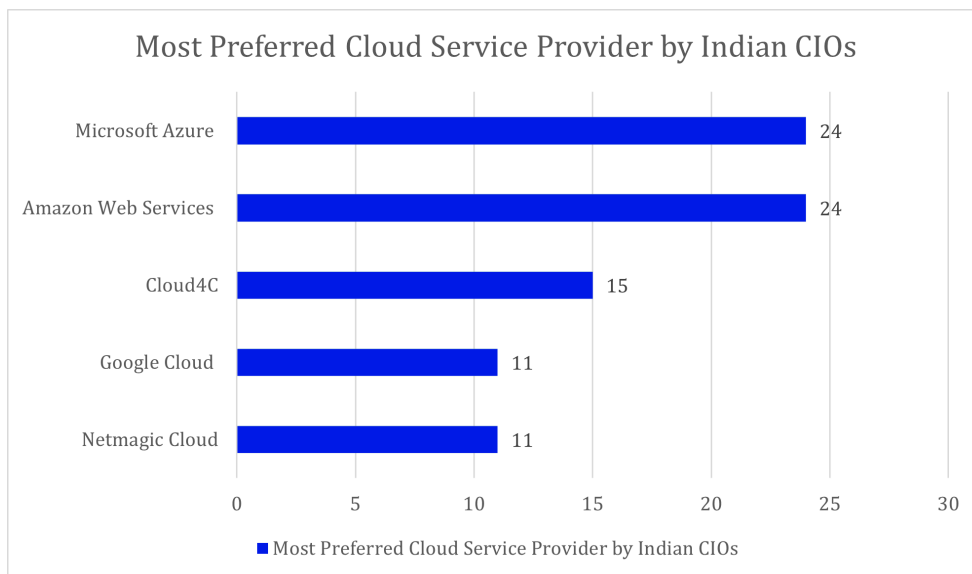


Figure 2: Overview of the most preferred cloud service providers in India (Source: Enterpriseworld Survey)

Overall, the experts we interviewed felt the Government's focus should be on increasing efficiencies in the infrastructure layer by facilitating the widespread rollout of 5G services and the development of a robust cloud services architecture. They said the availability of high-speed data and processing capacity at reasonable prices would play an important role in reducing the cost of AR/VR applications, which would facilitate the adoption of emerging technologies by enterprises and users alike.

Hardware

Hardware refers to the devices on which AR/VR experiences are rendered. The hardware requirement for AR and VR differ considerably, as AR experiences can be delivered using mobiles and other electronic devices, while VR requires specialised hardware such as headsets and haptic controllers. For this reason the supply chains for AR and VR hardware are assessed separately below.

AR Hardware

Since AR is an overlay of graphics on physical surroundings, existing mobile phones and other electronic devices with cameras and geospatial sensors can deliver realistic and compelling AR-based games and content. Indeed, the app stores for Android, iOS and Windows are flush with AR-based apps and games, with Pokémon Go being a leading example. Almost all stakeholders agreed that growing mobile penetration coupled with cheaper high-speed data and increasing tech literacy makes India a fertile ground for adopting new mobile-first technologies including AR. A few experts pointed to the rapid adoption of UPI and digital payments as evidence of Indians' increasing willingness to adopt mobile-based solutions. As of 2021 the country had 1.2 billion mobile subscribers of whom 750 million were smartphone users, and mobile penetration is set to cross the 100% mark in 2023, driven by the increased availability of devices and connectivity to Tier 2 and 3 towns and villages.²⁵ **With further improvements in smartphone processing power, we can expect to see growing adoption of AR in mobile games and applications by users, developers, and creators in the short run.**

Most stakeholders also felt that the demand for specialised AR hardware would likely be muted due to AR's mobile-friendly nature. Global trends echo the prediction. While leading technology companies including Google, Microsoft, Snap, and Magic Leap have launched their dedicated AR products, these have seen limited uptake by users. For example, Magic Leap sold just

about 6,000 units of its USD 2,300 AR headset in the first six months against an expectation of 1 million sales in the first year.²⁶ Similarly, Snap, which uses AR heavily in its apps, reported having lost nearly USD 40 million on its AR-enabled Spectacles due to ‘excess’ inventory reserves, or a lack of sales.²⁷

Two stakeholders pointed out, however, that Apple’s entry into the AR hardware space could be a game changer. The company has a proven track record of fuelling the adoption of new devices, including smartphones and smartwatches. Experts suggest that Apple’s AR glasses are in the early stages of development and may be revealed in the coming years.²⁸ There are also signs of renewed enthusiasm for investment in AR devices among other leading technology companies: Google has acquired several AR-related startups, including North,²⁹ a Canada-based smart glasses producer, and Raxium,³⁰ which develops LEDs for augmented and mixed reality applications. Snap acquired WaveOptics, an augmented reality glasses manufacturer, for USD 500 million in 2021.³¹ Whether the new generation of AR hardware products fares better than its predecessors remains to be seen.

In the Indian context, stakeholders expect Reliance Jio to play an important role in the AR hardware space. The company acquired Tesseract, a Mumbai-based mixed reality firm, in 2019. The first edition of the Jio Glass, developed by Tesseract, was recently showcased at the India Mobile Congress. Experts state that Jio’s ability to create an affordable AR headset suited to Indian consumers could see it gain a significant chunk of the market. It is also one of the few companies in India to operate across infrastructure, hardware and software, giving it a competitive edge.

VR Hardware

As noted earlier, VR requires the use of specialised headsets and devices. VR devices range in complexity and sophistication from simple cardboard-based headsets that work in conjunction with mobile phones to standalone units complete with handheld sensors for haptic feedback. As VR headsets remain prohibitively expensive and inaccessible to most of the Indian user base, in the short term stakeholders expect the demand for VR devices in India to resemble that of gaming consoles when they were initially launched, i.e. demand fuelled by a small segment of the population that has the means and interest to purchase them.

With increased global investment, however, VR systems will likely become cheaper and more accessible. Continued movement in this direction could mean greater adoption in the Indian market, characterised by relatively

limited disposable income, in a horizon of a few years. Indeed, some industry experts believe that the market for VR devices will eventually be much larger than for AR. One expert even suggested that the market for VR devices and wearables would rival the market for mobiles and laptops.

At present, US and Chinese firms dominate the global market for VR headsets. As of Q2 2022, Meta accounted for 66% of the worldwide share of XR headset shipments. Pico and DPVR, both Chinese companies, make up a combined 20% of the global share.³² No Indian company ranks in the top 20 manufacturers. The experts we interviewed did not find the early dominance of the US and Chinese firms in VR hardware surprising. They explained that manufacturing VR headsets requires many of the same linkages and expertise as other contemporary forms of hardware, which are abundant in the US and China. For example, both nations are among the leading importers and exporters of the integrated supply chips crucial to electronics manufacturing.³³ Stakeholders suggest that the absence of such links is hampering the establishment of VR headset manufacturing units in India.

Stakeholders also emphasised that manufacturing VR headsets will need significant research, development and innovation. At present, US and Chinese firms are at the forefront of research and innovation in this sector: the US, China and South Korea were the three leading jurisdictions in terms of AR/VR related patents granted in Q3 of 2021.³⁴

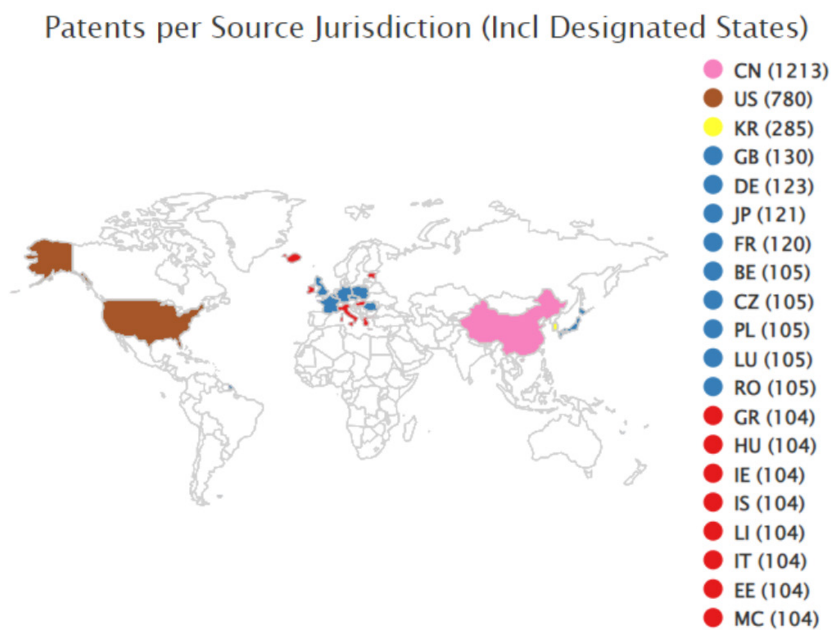


Image 5: Countries with the highest number of AR/VR patents in Q3 2021
(Source: Finnegan, Henderson, Farabow, Garrett & Dunner, LLP)

India does not feature in the top 20 jurisdictions. The domestic ecosystem's inability to create innovative products that capture the world's imagination was cited as a key obstacle to VR headset manufacture in India.

Other obstacles to establishing VR manufacturing capacity in India include the complex land acquisition process and stringent labour laws. A stakeholder summed up these challenges in the following manner:

“the problems associated with acquiring land, for manufacturing getting the right power, which you hope that the grid provides as opposed to making your own arrangements, to then the labour related issues, the obstacles on those ends are far higher.”

While most stakeholders agreed that India was unlikely to manufacture high-end VR headsets, they identified lower-end devices catering to Indian users in Tier 2 and 3 cities and villages as a potential market for domestic firms. The peculiar characteristics of these settings, such as limitations on space and slower connectivity, are not compatible with the leading VR headsets manufactured today. Indian entrepreneurs are uniquely placed to address these problems as they understand the specific context and requirements of Indian settings. Moreover, the blueprints for low-cost VR devices are often made public by leading manufacturers: Google provides a manufacturer's kit for its Cardboard VR product that anyone can use to create a basic smartphone-compatible headset.³⁵ An expert we spoke to said that his company's first product was based on the Cardboard VR blueprint and that they used open SDKs to develop other products as well.

In summary, experts expected the dominance of US and Chinese firms in VR hardware manufacturing to continue, with Indian firms possibly acquiring a foothold in the market for devices that cater to Indian users.

Software

This report uses software to mean the platform or operating system used by AR/VR devices. The nature of the platforms used by immersive devices will go a long way in determining how the larger ecosystem around them evolves. Broadly, there are two pathways this evolution may take.

Walled Gardens

The first approach, analogous to current smartphone and gaming console platforms, is characterised by closed platforms or 'walled gardens' typically

controlled by the manufacturer. For instance, Apple devices run on iOS and macOS, the development of which is controlled entirely by Apple. Consequently, it controls the functionalities available on a device, the distribution of apps and games on the platform, as well as the payment systems that can be used to pay for purchases.³⁶ Similarly, Microsoft and Sony control the development of their respective Xbox and PlayStation platforms and decide which gaming titles to make available to users and how to facilitate in-app purchases.³⁷

A stakeholder explained that the safeguards afforded by closed-source development and intellectual property rights were necessary for firms to capitalise on their value proposition and ensure long-term sustainability. Proprietary elements also allow businesses to differentiate themselves and provide unique experiences within AR/VR mediums. But the walled garden approach has several downsides as well. It focuses on locking consumers into a single device ecosystem and is characterised by a lack of interoperability between different platforms. Developers meanwhile must configure their apps or games for different devices, as the development standards and kits vary significantly between brands.

Adopting a walled garden approach for AR/VR devices would mean that leading manufacturers, such as Meta and Pico, control the platforms used on these devices. This would presumably enable the control of the larger ecosystem's development as well. There is some evidence that AR/VR devices will also go the walled garden route. For instance, Meta takes a 30% transaction fee for any payments on their Oculus systems, including for games, apps and in-app purchases, a situation reminiscent of the debates surrounding fee structures for the app stores on iOS and Android.³⁸ About half the interviewed experts suggested we are likely to see a repeat of the walled garden approach with AR/VR devices. They stated that major global corporations, including Meta, Google and Apple, will likely dominate the devices market and its platforms and ecosystems. As a result, Indian companies will largely be limited to developing the apps and content hosted on these platforms.

Open Source

Other respondents believed that the ethos and momentum behind open-source technologies is greater than ever before. Open-source software is software where anyone can inspect, modify or enhance the source code. In the modern sense, open-source refers to an ethos that celebrates open exchange, collaborative participation, transparency and community-oriented development. This is in direct contrast with the walled garden approach, where

the source code is only accessible to key members of the organisation that owns the code, and safeguarded by robust intellectual property laws. Open-source elements at the infrastructure layer would allow interoperability and better harmonised standards, resulting in a more competitive environment, with consumers experiencing greater discretion and choice.

Experts stated that the experiences of developers and tech enthusiasts with closed ecosystems have made them wary of the walled garden approach and reaffirmed their commitment to open-source technology. The move towards decentralised and permissionless systems exemplified by blockchain and Web 3.0 technology illustrates this commitment. Several experts think the momentum for going open-source in allied fields, including artificial intelligence and 3D printing, will carry over to immersive technologies, and AR/VR devices will eventually adopt open-source protocols that aren't controlled by a single entity. Recent developments in the field of immersive technologies suggest this may well be the case. For instance, an increasing number of headsets, including some Oculus, HTC, Steam and Microsoft headsets are now compatible with OpenXR, a royalty-free open standard maintained by the Khronos group.³⁹ Similarly, several big tech companies including Meta and Twitter have formed the Metaverse Standards Forum, where they will cooperate to build interoperable standards for an open metaverse.⁴⁰

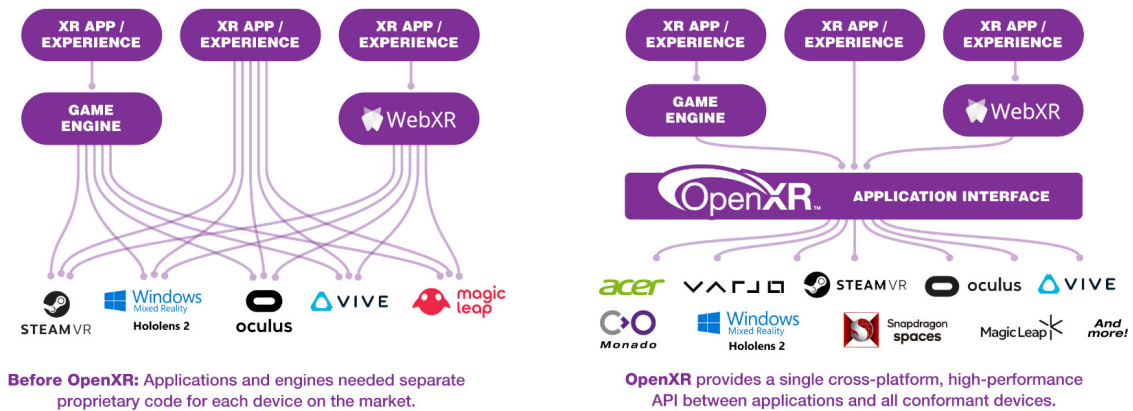


Image 6: An overview of the walled garden and open-source approaches to software development (Source: Khronos Group)

It was suggested in some interviews that the open-source route may work in India's favour as the country possesses immense potential to build on open-source technologies and take them to scale. An expert explained the dynamics at play:

“I hope our ability to spin up scale from easily available open-source technologies will provide a leg up. This is not the case where it was 40 years ago. So back in the 80s, you couldn't necessarily pull out a bunch of those blueprints and just reverse engineer technology unless you had some kind of back-to-back licensing agreement with those entities, and that required your own set of scale. I 100 % see the open-source approach driving value and India's role would be essentially to leverage the ability to take scale off of that IP essentially, rather than necessarily having to ideate and build its own set of IP and then take it to scale”. Indeed, the ability of Indian developers and entrepreneurs to build global products and services using open-source technologies is illustrated in the blockchain and Web 3.0 domain with projects such as Polygon, which is the leading scaling solution for the Ethereum blockchain. With geographical homogenisation growing after the pandemic, some experts suggest that it would not be surprising if the leading open-source solution for the AR/VR ecosystem emerges from a country like India.

Overall, it is too early to predict which of the two approaches will gain traction in the AR VR industry. While there is considerable momentum behind open-source technologies, the importance of proprietary or closed aspects cannot be overlooked as they generate revenue and facilitate sustained investment in innovation by companies. A walled garden approach is likely to favour major hardware manufacturers, primarily from the US and China, while an open-source approach could benefit India's expertise in scaling pre-existing constructs.

Content

Content is used in a broad sense to include games, applications, movies and shows that contain elements of AR and VR. **Most experts agree that content creation is the supply chain segment in which India has an advantage over**

other countries, one it should look to exploit by promoting the creation of content focused on Indian consumers.

India has emerged as one of the leading producers of high-quality animation and games in the last five years. The animation and visual effects for leading films, including Blade Runner 2049 and Interstellar, were done by Indian studios. India remains the preferred destination for outsourcing animation and VFX due to the availability of skilled human resources at a fraction of the cost in other countries. The same is true for software development, with India being the world's second largest exporter of ICT services.ⁱⁱ Experts expect India's expertise in app development and content creation to spill over into the AR/VR domain, with existing animation, game development and VFX companies upskilling to provide immersive content. The trend already seems to be underway, with several leading Indian studios, including HyperLink Information Systems, MonkHub and Queppelin offering advanced AR/VR-based solutions to their clients.

The growth of the AR/VR content industry will also be fuelled by robust domestic demand, particularly for domestic and localised content. Several stakeholders were of the view that increased content consumption by Indians due to increased mobile penetration and data availability has created a large market for regional and local content, particularly in Tier 2 and 3 towns. They pointed to the OTT industry as an example of the robust growth of localised media and entertainment in India. OTT platforms such as Hoichoi (Bengali), ManoramaMax (Malayalam), Oho, Super (Gujarati), Planet Marathi (Marathi), SunNXT (Tamil, Telugu), Kanchanka, Tarang Plus and Aao TV (Odia) which focus exclusively on regional-language content have seen robust subscriber growth in recent years. Large OTT players such as Netflix and Amazon Prime have also bolstered their libraries with regional content, which is expected to constitute more than 54% of all content on such platforms.

ii. ICT services include software development, business process outsourcing and other allied activities.

OTT Players Offering Regional Language Content

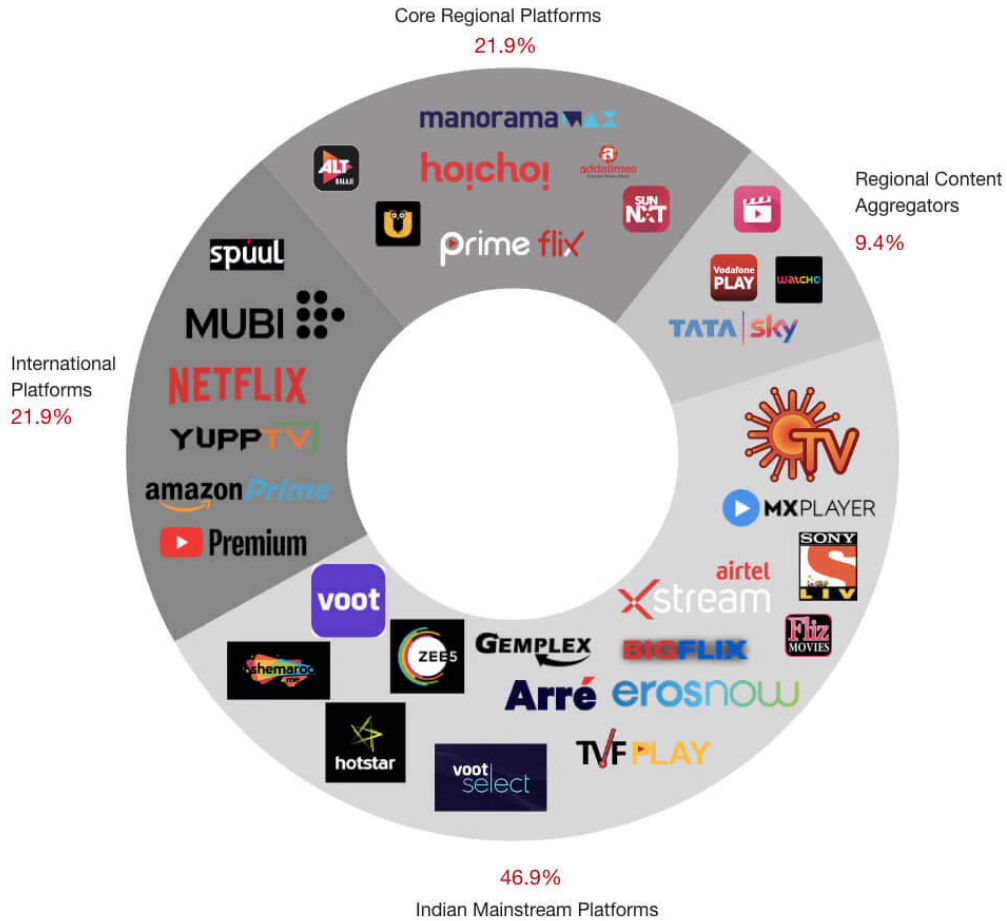


Image 7: Increasing availability of regional content on OTT platforms (Source: Inc42)

With mobile-first applications of AR becoming more mature, experts predict a blossoming in demand for games and content that are uniquely Indian in their themes and overtones. They state that Indian creators and developers are best suited to meet the demands for such content. Indian studios, such as The Happiness Room, are already developing games and other content based on Indian themes, such as the nation's history and mythology. One expert noted:

“India’s strength would probably come from a content space and creation of content for the Indian consumer. I think when it comes to understanding the Indian consumer from a more heart and soul perspective, that’s where the Indian companies will do a lot better.”

3. ASSESSING SKILL DEVELOPMENT AND READINESS FOR IMMERSIVE TECHNOLOGIES

Rapid growth in the gaming, animation and visual effects sectors will require a talented workforce comprising game developers, game designers, front-end and back-end engineers, product managers, and 3D modellers.⁴¹ Further, AR/VR is a new field that is constantly evolving. VR creators need to be familiar with the hardware used. This section outlines where India's workforce currently stands, the challenges that affect it and how these problems may be resolved.

Current Status

India has the potential to become a talent hub for AR/VR. It is one of the world's largest offshore IT and BPO destinations, because of its large pool of talented workers with English language proficiency.⁴² It also has one of the fastest-growing concentrations of software developers in the world, with nearly 5.8 million currently employed in India.⁴³ The country's emergence as a preferred destination for animation and VFX has also resulted in the creation of a skilled creative workforce. VFX, animation, and virtual production pipelines are driven by talent pools akin to those in the AR/VR field. As India's prominence in the global VFX and animation landscape grows and talent pools become more robust,⁴⁴ we can expect much of this newly upskilled talent to spill over into the XR space. As one expert said:

"I definitely see a huge role for our talent simply because I see this on the web3 side from a general development perspective. It plays into the gaming and content creation fields as well. The sort of return on investment that you get from Indian talent is much greater than what you can get anywhere else."

While the talent base for AR/VR development and content creation exists, certain challenges may prevent the country from achieving its full potential. These stem largely from deficiencies in AR/VR-specific training and skilling provided to students at the school and college levels. Experts agreed that the current education system is not equipped to produce engineers and creators

who are employable and possess AR/VR-specific domain knowledge. One stakeholder observed:

“If you look at engineering talent, roughly only 5% of Indian engineers are really employable. There is an additional 50% which is barely borderline, which means they require just a little bit of upskilling/enhancement of education.”

A survey by Scaler, an edtech startup, reported that of the 15 lakh engineers who graduate from India every year, only 2.5 lakh obtain jobs in relevant technical domains.⁴⁵

The lack of industry-readiness of Indian graduates in AR/VR was attributed to the outdated nature of college curricula, the lack of AR/VR devices at the school and college levels, and the shortage of expert trainers in the field. Stakeholders noted the curricula in most institutions remain focused on the theoretical aspect of learning with little attention to the practical or experiential. Indeed, the opportunity for students to have hands-on experience with AR/VR devices is limited as institutions are unable or unwilling to procure these at high cost. There is also a dearth of expert trainers who have a practical understanding of how the technology works.

Since fresh graduates lack the necessary industry readiness, companies inevitably incur the cost of training them for a few months before they can make any kind of value addition in their jobs. One stakeholder regretted that the burden of the education system is often placed on the software industry, but recognised that it was necessary given the circumstances. Another observed that it is common practice for IT companies to pay fresh graduates a low salary during the first year or so while simultaneously training them during that period. This is often treated as an investment by the companies to develop a talented cohort of employees who are equipped with the exact skillset the company needs.

Deficiencies in college curricula have also resulted in less importance being given to potential candidates' educational degrees and qualifications. An expert stated that he no longer gives a lot of importance to degrees and instead prioritises candidates with an analytical and quantitative skillset. He said these qualities are often present in graduates from reputable universities, but he treats their degrees as validation of a hiring decision as opposed to a prerequisite. Instead of relying on college degrees, importance is given to candidates' experience in creating and deploying projects in the relevant field regardless of their age. As a result, students at the school level or in

the early years of college who have acquainted themselves with the relevant programming languages and design tools are able to land jobs that were earlier limited to college graduates. One stakeholder noted, *“Some of our interns who are second-year students sometimes perform better than some of our experienced employees. This is because students these days are getting acquainted with technology and software development as young as six years old!”*

Experts suggested this trend was particularly strong in the Indian web3 development ecosystem and will likely spill over to AR/VR development.

In addition to creating employable and industry-ready talent, India also struggles to retain its leading developers and creators. Experts attribute this trend to the large investments made by companies abroad in R&D and talent retention and acquisition. The ethos of innovation and creativity underpinning many of the foreign companies was cited as another reason they are more attractive to Indian talent than their Indian counterparts.

In conclusion, experts were unanimous in their view that India has the necessary talent base to be a leading creator and developer of AR/VR applications, content, and games. With the requisite upskilling and training, the workforce will be positioned to serve not only the needs of domestic enterprises but the larger global market.

4. THE WAY FORWARD

There is great optimism about India's role in developing and making use of immersive technologies. The nation's IT and content creation expertise, coupled with a large talent base, should allow it to play a leading role in creating content, software and even devices. At the same time, virtually all the experts we interviewed agree that realising this potential will require a supportive policy framework. Indeed, governments at the forefront of entertainment innovation, such as South Korea's, have already responded to these developments, with its Ministry of Science and Information and Communications Technology announcing an investment of at least USD 187 million to boost the country's metaverse capabilities and make it a hub of future-oriented digital industries. Stakeholders suggest that the Government of India take up similar policy interventions to boost the domestic immersive technology ecosystem. Some interventions that the Government, along with other stakeholders, can consider are outlined in the following paragraphs.

The first challenge is the treatment of immersive technologies in existing legislation. Experts note that there needs to be more clarity on how companies creating AR/VR devices and content will be treated under laws such as the Goods and Services Tax Act and the Customs Act. Private executives and government functionaries found it hard to classify their work under the existing categories, negatively impacting the ease of doing business for such firms. Guidelines or regulations that clarify how such companies are to be treated would go a long way in facilitating the creation of globally competitive Indian AR/VR companies.

Another key challenge faced by Indian AR/VR companies is gaining access to finance from abroad. One expert noted that the relevant authorities view funding from abroad with suspicion. He also pointed to the complexities of the Foreign Exchange Management Act as a key impediment in attracting foreign capital. The FEMA regulates cross-border transactions in India, and requires all such transactions to be routed through identified dealers and be within the prescribed limits. Such limitations are necessary as India has a managed capital account. Yet they can also impede the flow of capital from foreign sources to Indian entities. The inability to attract capital constrains the amounts that Indian companies can invest in research and innovation, affecting their competitiveness against global counterparts. A more liberalised regime for AR/VR products and other emerging technologies would allow

Indian companies to take on greater risks and create innovative products, content and services.

While access to finance and clarity under existing legal regimes are squarely within the government ambit, other aspects, such as innovation and skilling, would benefit from a collaborative approach between the public and private sectors. For instance, experts suggested collaborations between Government and industry in hosting hackathons and setting up incubators to encourage the development of immersive technologies and content. Such hackathons and incubators should focus on supporting innovations that respond to India's unique requirements, as outlined in the preceding sections. Grants and scholarships funded by the private and public sectors similarly could foster cutting-edge research in immersive technologies.

Skilling is another aspect that would benefit from policy intervention, according to most experts. They noted that the Government sets the overall educational curriculum and hence bears the responsibility to ensure that it is updated to meet the needs of emerging technologies, including AR and VR. They also suggested that the Government could create a significant impact by introducing internship and skill-development programmes at the school and college levels. As part of these programmes, students can gain the necessary hands-on experience and practical learning to improve their employability and industry readiness.

Several state schools in Tamil Nadu, Andhra Pradesh and Nagaland have introduced Augmented Reality and Virtual Reality modules in the course curriculum for middle-school students.⁴⁶ This is in line with a circular issued by the Central Board of Secondary Education directing schools to introduce a skill module on AR-VR for middle school students.⁴⁷ Besides changes in curricula and skill development programmes, the Government can play a major role in changing the messaging around creativity in educational institutions. Opportunities in creative fields, such as animation and game development, should be brought to the notice of parents and students to promote greater uptake of such career paths.

At the same time, experts said that skilling and training must eventually respond to the needs of the private sector. They argued that nobody knows market needs better than the private sector and that upskilling programs should be specifically designed to meet these needs. Several experts we spoke to are already implementing such skilling initiatives. For example, one of the stakeholders had helped set up several XR labs in schools and colleges. These labs are intended as Centres of Excellence that provide individuals with all

the tools they need to develop their skills in the field. Yet another stakeholder had played an important role in the creation of 'Tinkerers Lab', an initiative that gave students infrastructural support to boost innovation and build their skills. The NITI Aayog has also set up more than 10,000 Atal Tinkering Labs in schools to facilitate student access to tools and equipment that can help teach concepts of science, technology, engineering, and math. Similar labs can be set up at the school and college levels using a PPP model to facilitate access to immersive technologies and expert trainers at a progressively younger age, to help create a skilled and industry-ready workforce.

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