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Advanced Learning Technology Research

The 2018-2023 Worldwide Mixed Reality Learning Market

Revenues Will More than Double by 2023

Analysis by: Sam S. Adkins
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About Metaari

Metaari (formerly Ambient Insight) is an ethics-based quantitative market research firm that identifies revenue opportunities for advanced learning technology suppliers.

Metaari publishes quantitative syndicated reports that break out revenues by customer segment (demand-side analysis) and by product category (supply-side analysis). Our forecasts are based on our industry-leading advanced learning technology taxonomy.

We track the learning technology markets in 122 countries. We have the most complete view of the international learning technology market in the industry. Metaari focusses solely on advanced learning technology research on products that utilize psychometrics, neuroscience, game mechanics, robotics, cognitive computing, artificial intelligence, virtual reality, and augmented reality.

About the Analyst

Sam S. Adkins is the CEO and Chief Researcher at Metaari. Sam has been providing market research on the global learning technology industry for over twenty-five years and has been involved with electronic training technology for over thirty-five years. Sam is an expert at identifying revenue opportunities for learning technology suppliers.



Dubai, United Arab Emirates, 2013 (Photography by Tyson Greer)

Sam was the co-founder and Chief Research Officer for Ambient Insight between 2004 and 2016 before rebranding the company to Metaari in early 2017. Sam was a business development manager for Microsoft's Training and Certification group. During his eight years at Microsoft, he managed the Advanced Knowledge Engineering team that built the world's first commercial online learning business (The Microsoft Online Learning Institute). Prior to that, he was a Senior Instructional Designer at United Airlines.

Before United Airlines, Sam was the manager of the Instructional Animation and Graphics Lab at AT&T's central computer-based training (CBT) facility for four years.

Sam Adkins and Tyson Greer founded Ambient Insight in 2004. Ambient Insight ceased operations in late 2016 and rebranded as a new company named Metaari that launched in January 2017.

"Ambient Insight has been in operation for twelve years and we have a well-respected brand and a very successful company," comments Adkins. "The global learning technology market has changed dramatically in the last few years and the new advanced learning products coming on the market essentially represent a 'brave new world' in education. We want to be an active part of this new world and launched our new company to focus on these incredible innovations."



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Executive Overview: Profound Innovation and Transformation

The growth rate for Mixed Reality Learning across the planet is a healthy 15.9% and revenues will surge to \$9.9 billion by 2023. The revenues are heavily concentrated in North America and Asia Pacific throughout the forecast period.

Over 600 suppliers operating in 122 countries across the globe are identified in this report to help suppliers locate domestic partners.

Mixed Reality (MR) is defined as an integration of simulation, location-based learning, Augmented Reality (AR), Virtual Reality (VR), and the biophysical environment along an immersion spectrum. This immersion spectrum is described in the Mixed Reality Immersion Spectrum section of this overview. Mixed reality often referred to as XR.

This is an evidence-based quantitative report. A great deal of effort has been made to identify suppliers competing in the 122 countries tracked by Metaari. This report identifies the companies that operate in specific countries and regions; it also identifies the types of products they sell and their primary customers.

This report also identifies specific buyers by company, academic organization, and/or government agency providing suppliers with potential sales leads. This provides invaluable insight on the top buyers across the globe, the best-selling products, and the most successful suppliers.

The global market for Mixed Reality Learning is in the midst of profound innovation and transformation (if not outright disruption). These innovations are exponential in the sense that they are not small incremental linear innovations common to traditional products; they are fundamentally new types of learning products. The one common characteristic of these new learning technologies is that they enable real-time performance improvement.

In educational psychology, there are two phases of the learning process: knowledge transfer and learning transfer. Knowledge transfer is the transmission of information and skills to the learner. Learning transfer is the ability of the learner to demonstrate mastery in a real world setting. ***Next-generation Mixed Reality products (particularly the new augmented performance support products on the market) effectively accomplish both phases simultaneously.***

The current Mixed Reality Learning market is being driven by the demand for products in the industrial verticals, military agencies, and healthcare sectors in the developed economies. The demand for tourism and travel experiences is now present in both developed and developing economies.

China's NetEase announced their new \$30 smart glasses at CES 2018. "The AR glasses are equipped with a handheld display with plans to apply this technology to games, education, and training."

The market dynamics will change over the forecast period as AR and VR headset prices continue to fall and more packaged retail content becomes available for the academic and consumer segments. The markets in developing countries that are mobile-only (concentrated in Africa, Asia, and Latin America) will be able to experience AR, but PC penetration is low in many of these countries and until tether-less VR headsets are widely available, VR adoption will be quite slow in mobile-only countries.

The launch of Apple's ARKit and Google's ARCore SDKs in 2017 is a major catalyst for Mixed Reality Learning going forward. There will be billions of phones with native AR support in just 2-3 years.

One catalyst in the global PreK-12 segments is the increased availability of so-called VR classroom kits that include multiple headsets, routers, chargers, a teacher tablet, carts, and preloaded educational content.

In 2017, Facebook donated Oculus classroom kits *to every high school in Arkansas* as part of their TechStart initiative. As the classroom kits proliferate, the delivery channel expands. Mixed Reality Learning content suppliers like MEL Science and Unimersiv are already collaborating with classroom kit providers. An interesting classroom kit product from the UK's ClassVR includes a headset that enables both AR and VR.

Taiwan's headset maker HTC launched a ten-student classroom bundle called the Vive Group Edition in May 2017. HTC is targeting the Chinese PreK-12 market so far. Lenovo launched their classroom kit bundle called Lenovo Virtual Reality Classroom in January 2018. It includes Daydream headsets and over 700 Google Expeditions. Best Buy Education (the retailer's education division) sells a VR classroom kit as well.

Suppliers are priming the PreK-12 and consumers markets. Google pioneered VR for the schools when they launched their Cardboard Expeditions product in 2014. In March 2017, they announced that they had shipped over ten million Cardboard headsets. "We first launched

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Cardboard in 2014 as a simple and affordable way for everyone to try virtual reality. With only Cardboard and the smartphone in your pocket, you can travel to faraway lands, ride a roller coaster, or take a guided tour of the solar system. Today, more than 10 million Cardboard viewers have shipped worldwide. There have been 160 million downloads of Cardboard apps on Google Play—*and 30 of those apps have more than 1 million downloads.*

Educational broadcasters are seeding the academic and consumer markets with high quality VR-based documentary content. National Geographic, Discovery, and the BBC have all released compelling VR content in 2017 and 2018.

Discovery Education sold products and services in one out of three classrooms in the US. In 2015, they launched their Discovery VR business that now includes over 160 experiences. In 2016, they started integrating VR into their digital products called Techbooks. They released three new conservation-related VR experience in late 2017.

The BBC's first experience on HTC Vive, A VR Spacewalk, was released in November 2017. Space-related VR experiences are particularly popular with consumers. The BBC opened a dedicated VR development hub called VR Hub in December 2017 "that is going to invest in the creation of virtual content. VR Hub will look to bring these collective efforts under a collective banner, and act as an internal center to unite program makers and digital experts."

The BBC released two new VR experience in February 2018: one about the Nile and one about their Blue Planet Series called BBC Earth. A custom development company in London called Preloaded developed the Blue Planet experience.

There is a concentrated effort to implement AR and VR instructional programs in the global higher education segments. This trend is accelerating as the demand for developers skyrockets across the globe. There is mounting evidence of an imminent skills shortage as demand outstrips the number of skilled designers and developers.

Universities and community colleges are launching AR/VR programs at a steady rate. On average, at least two new university AR/VR programs are announced every week across the planet.

One of the latest is the AR/VR Research Lab launched at the University of Washington in January 2018 with \$6 million in funding from Facebook, Google, and Huawei. Many universities develop their own Mixed Reality programs but there are third-party alternatives.

A global initiative called VR First had deployed VR training facilities and software bundles in over 60 higher education institutions (including 24 in the US) by December 2017. "The overarching goal of VR First is to nurture new talent in VR development and create a global community equipped to embrace this exciting field of technology."

VR First announced their Academic Purpose VR Bundle in December 2017. Partners include Intel, HTC Vive, Leap Motion, CDWG, Futuremark, MixCast, SpringboardVR and Senses Global.

VR First launched nine new VR training labs in December 2017 in universities in South Africa, Belgium, Kosovo, Turkey, Bangladesh, Vietnam, China, Colombia, and Brazil. VR First reports that 35% of the projects in the VR First initiative were related to games, but 7% were related to education and 7% to tourism; both are by definition educational.

EON Reality is a global VR/AR company that specializes in Mixed Reality Learning. They sell Mixed Reality Learning tools and platforms. They also train college students in VR and localize their existing content for specific regions. In a partnership with universities across the planet, they operate fifteen VR Innovation Academies (VRIA) including five in the US, two in the Middle East, and one each in South Africa, Mauritius, Canada, Belgium, the UK, Norway, China, and South Korea.

Outside the US, the EON's VRIA locations are called Interactive Digital Centers (IDCs). IDCs "are regional Augmented and Virtual Reality Centers designed to help enhance regional knowledge transfer and grow a region's digital economy. IDCs also develop applications targeted at specific regional needs, localize existing EON Reality content, and educate the next generation of AR and VR professionals."

A large amount of Mixed Reality Learning is developed on the Unity or Unreal Engine platforms. Both Unity and Epic's Unreal Engine offer free academic licensing models.

- "Unity now offers software licenses at no charge for in-class instruction to qualifying academic institutions at any level. Educators are welcome to apply for the Unity License Grant Program on behalf of their institution or program." Unity also provides the free license to secondary schools.

- "Free to use, Unreal Engine 4 can be downloaded and installed to classroom computers as well as personal systems at no cost. With full access to the complete source code and tools, Unreal Engine 4 levels the playing field to give everyone the resources needed to learn professional-quality development." Unreal has over 200 academic partners across the globe training students in VR.

Unity also has Unity Centers of Excellence (COEs) in the Asia Pacific region. COEs "are learning centers located in India and Asia Pacific that accelerate the development of quality interactive content in immersive technologies like VR and AR across a wide variety of industry verticals."

Japan-based Psychic VR Lab sells a web-based VR authoring tool and distribution service called STYLY. They offer free workshops to universities on VR development across the Asia Pacific region including China, Japan, India, and Pakistan. They delivered workshops in fifteen universities in Pakistan in February 2018 alone.

One "consequence" of the higher education move to AR/VR programs is the growing use of Mixed Reality in the curriculum. The use of Mixed Reality tends to be concentrated in STEM programs so far, but the medium is now expanding into other programs.

In February 2018, US-based Full Sail University announced that they had licensed the VR collaboration platform from Doghead Simulations called rumii. The University intends to use it across all their programs as an enhanced online learning medium. It is one of the first institution-wide implementations of VR as a learning delivery platform.

The Mixed Reality Immersion Spectrum

For the purposes of this report, Mixed Reality (MR) is defined as the ***experience*** of simulation, augmented reality (AR), and/or virtual reality (VR), and the biophysical environment along an immersion spectrum.

In AR, the user is still fully aware of the physical environment and the experience is semi-immersive. There are two types of augmented reality: AR triggered by objects and AR projected into the actual environment.

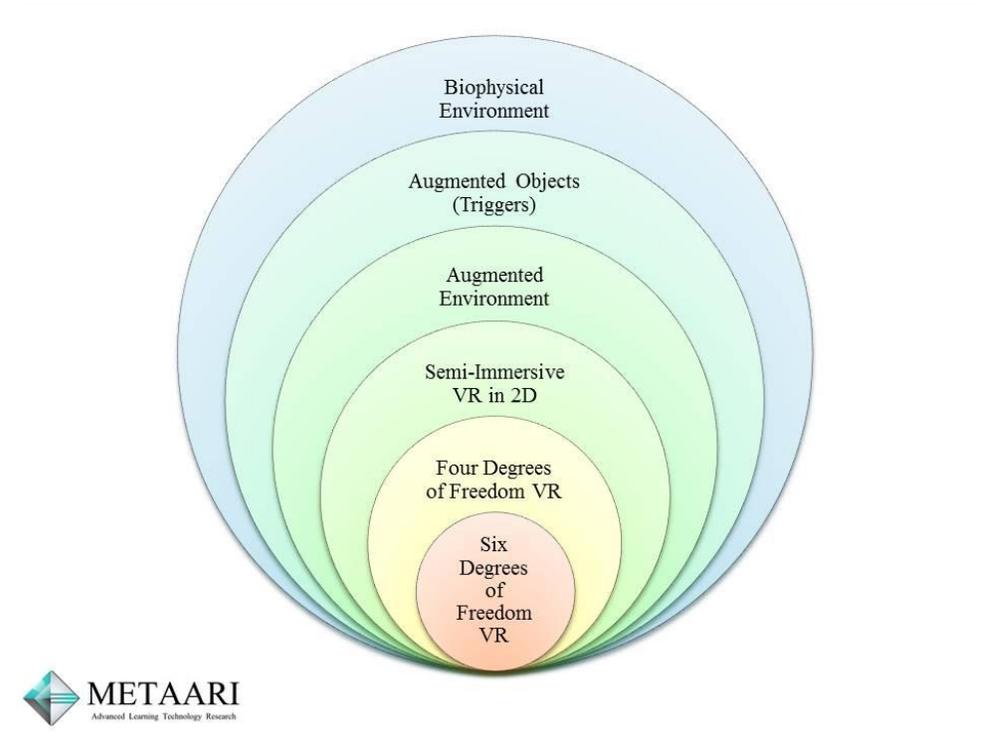
Location-based Mixed Reality Learning experiences found in exhibitions and tourist attractions are still mostly triggered by object recognition,

geotags, print-based markers, beacons, RFID chips, barcodes, and sensors, collectively known as triggers. The location of the object triggers the experience; the user finds the object and intentionally activates the trigger.

New technology now focusses on the location of the user and takes full advantage of the range of smartphone GPS chips and sensors including the gyroscope, compass, altimeter, and the accelerometer. Essentially, *the object finds the user* and automatically triggers the augmented content.

The Microsoft HoloLens platform is a good example of technology that overlays augmented content onto the actual environment. The education content developed for the HoloLens is projected into the real world.

Figure 1 – The Mixed Reality Immersion Spectrum



Semi-immersive VR still makes up the majority of virtual educational products on the market. These include educational virtual worlds like MathBlaster and simulation training products for the corporate and government segments. They are experienced on a 2D screen and only approximate virtual reality.

True virtual reality is usually experienced in immersive 3D with the aid of a headset and other peripherals. It should be noted, that there are physical virtual reality rooms and domes that enable the user to experience VR without the use of headsets.

There are two types of immersive VR products: those with four degrees of freedom (4DoF) and those with six degrees of freedom (6DoF). The four degrees are up, down, left, and right. A user can move in these four directions but cannot move forward or backward. They can be simulations or actual 3D videos. Google's Cardboard Expeditions is a good example of a 4DoF educational product.

The six degrees of freedom include the addition of forward and backward to the four degrees. A user can move in all six directions. Developing 6DoF VR products is still very expensive to develop requiring a high-end modeling platform (or gaming engine) and/or automatic spatial tracking imaging hardware, 6DoF cameras, and software tools.

The prices for 6DoF cameras and automatic spatial mapping tools are dropping fast and relatively inexpensive products are already hitting the market. This trend will accelerate over the forecast period.

Google's new Earth VR (launched in November 2016) is a quintessential 6DoF VR educational product. IndustrialVR developed by the company of the same name is also a good example. IndustrialVR has offices in the US and Ukraine. "IndustrialVR sells a game designed to show and explain workflow and general concepts of complex industrial sites."

Even in fully immersive VR experiences, there is a sense of physical presence, sometimes referred to as embodied cognition. Headset controls motion trackers, and haptic devices are in the physical world. Users interact with VR environments with body movements, eye movements, hand gestures, and voice. There are even products on the market that can recognize emotions via biosensors and facial recognition.

Primary Catalysts Driving the Global Mixed Reality Learning Market

There are several primary and secondary catalysts driving the global Mixed Reality Learning market. Combined, these catalysts have created very favorable global market conditions for suppliers.

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One of the major advances in VR is the availability of haptic technology that simulates the sense of touch. This is having a dramatic impact on healthcare-related VR training.

That said, the opportunities are heavily concentrated in specific buying segments that buy very specialized products. This is particularly true for augmented performance support in the corporate verticals and the VR-based training in the healthcare training sector.

Figure 2 - Primary Catalysts Driving the Global 2018-2023 Mixed Reality Learning Market



The current global Mixed Reality Learning market is a lucrative value chain and the revenue opportunities are now quite abundant across the globe. The major catalysts contributing to the growing demand for Mixed Reality Learning products across the planet include:

- Native support in operating systems, in game engines, and on devices
- A surge in private investments flowing to Mixed Reality Learning startups
- The growing number of inexpensive and easy-to-use 3D modeling tools that continue to come on the market
- Extraordinary advances in VR-based Mixed Reality Learning products in the healthcare training and education sector
- The high demand for a new type of augmented performance improvement product in the industrial verticals

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- The exponential innovation in Location-based Learning (LBL) and augmented Location Intelligence
- The boom in demand for custom AR and VR educational content development services

A detailed analyses of these catalysts is provided in a dedicated section of this report. These catalysts are convergent (as opposed to sequential) and combined have resulted in a vibrant era of innovation and transformation in the global training and education industry.

Apple and Google have dramatically opened up the market for augmented mobile applications via the 2017 releases of the Apple ARKit and the Google ARCore SDKs. Both platforms make it much easier to develop AR apps, but perhaps more significantly provide native support for AR on the devices.

Going forward, all new releases of iOS and Android phones will have native support for AR; billions of devices will support AR in 1-2 years.

In February 2018, Google released their ARCore 1.0 version expanding support for several smartphone models including models from Samsung, LG, and Asus. ***As of February 2018, over 100 million phones across the planet are compatible with ARCore.*** At the time of the release, nine smartphone vendors announced that they would support ARCore in the next software releases.

Microsoft's latest releases of Windows now have native Mixed Reality features. Windows Mixed Reality was included in the Windows 10 Fall Creators Update that launched in late 2017. As of January 2018, there were four AR headsets available for Windows Mixed Reality including devices from Acer, Dell, HP, Samsung, and Lenovo.

New companies continue to bring advanced Mixed Reality Learning products to market and several of these companies are attracting large amounts of investment. A detailed analysis of the funding amounts and the companies funded is included in the analysis of the major catalysts.

All of the major technology players are now heavily invested in augmented reality and virtual reality including Google, Intel, Facebook, Sony, Apple, HTC, Intel, Dell, Samsung, PTC, Epic Games, Unity, and Microsoft.

Perhaps the most significant catalyst for the Mixed Reality education and training market is the full weight of the major technology giants that are actively backing the technologies.

Google's Cardboard headset essentially "democratized" VR in the consumer segment and jumpstarted the demand for educational VR content in the PreK-12 segment. The most common content shipped with the VR classroom kits across the globe is the Expedition catalog of over 700 experiences.

What You Will Find in This Report

There are three sections in this report: an analysis of the major catalysts driving the market, a demand side-analysis, and a supply-side analysis. The analysis of the catalysts provides a detailed discussion of the six major catalysts driving the global Mixed Reality Learning market.

The demand-side analysis breaks out five-year revenues forecasts for seven international regions and by six buying segments. Five-year forecasts are provided for seven regions: Africa, Asia Pacific, Eastern Europe, the Middle East, Latin America, North America, and Western Europe.

The Eastern Europe section includes a discussion on the vibrant custom content develop hub in Ukraine. The Western Europe section has a detailed analysis of the market in the Nordic Cluster, which is comprised of Denmark, Norway, Sweden, Finland, Iceland, Greenland, the Faroe Islands, and the Åland Islands.

The demand-side analysis includes five-year forecasts for six buying segments: consumers, PreK-12 schools, tertiary & higher education institutions, local/state/provincial/prefecture government agencies, federal government agencies, and corporations & businesses.

The supply-side analysis provides revenue forecasts for three major product categories: packaged retail content (further broken out by eight types), custom content development services, and authoring tools & platforms.

The supply-side analysis includes a detailed five-year forecast for eight types of packaged retail Mixed Reality Learning content including cognitive learning, knowledge-based, skill-based, language learning, early childhood learning, performance assessment, role-based behavior modification, and location-based learning.

All revenue forecasts in this market report are in US dollars (USD) at the international exchange rate in February 2018.

This report does not include forecasts for hardware devices, headsets, and equipment like 3D capture cameras and motion tracking peripherals used in Mixed Reality development.

That said, many augmented device suppliers license educational content development tools for their devices and those revenues are included in this report. Meta, ClassVR, and RealWear provide the hardware, but partner with content suppliers for the content.

Most commercial educational games on the market were built with commercial gaming engines, mostly Unity and Unreal Engine. Those are general-purpose engines and their revenues are not included in this report. However, revenues for packaged retail Mixed Reality Learning experiences built with those tools are included.

All revenue forecasts in this report are in US dollars set at the international exchange rates in February 2018. The impact of exchange rates only comes into play in countries with significant economic challenges.

Revenues in countries experiencing significant currency devaluation and inflation (like Venezuela and South Sudan and more than a dozen others) are not included in this report.

Metaari temporarily suspends tracking the learning technology markets in countries undergoing severe socioeconomic challenges and restarts the monitoring once the conditions stabilize.

Where are the Buyers?

Metaari tracks the learning technology markets in 122 countries and positions those countries in seven regions. While there can be similarities in buying behavior for some countries, they are usually confined to a particular buying segment.

In general, however, the buying behavior is usually quite different in each country, particularly in the consumer, academic, and government segments. Corporations across the planet are now adopting Mixed Reality Learning products at a rapid rate particularly in the industrial verticals, which tend to base operations in specific countries. There are regional suppliers that market to the industrial verticals and their revenues are concentrated in specific countries in the region.

There are other pan-regional revenue opportunities and Metaari identifies those for suppliers. For example, language learning products are in high demand across the globe and in specific regions like the Asia Pacific. English is in the highest demand in most countries (including the US). New AR and VR language learning products are now on the market.

Table 1 - The 122 Countries across the Seven Regions Tracked by Metaari

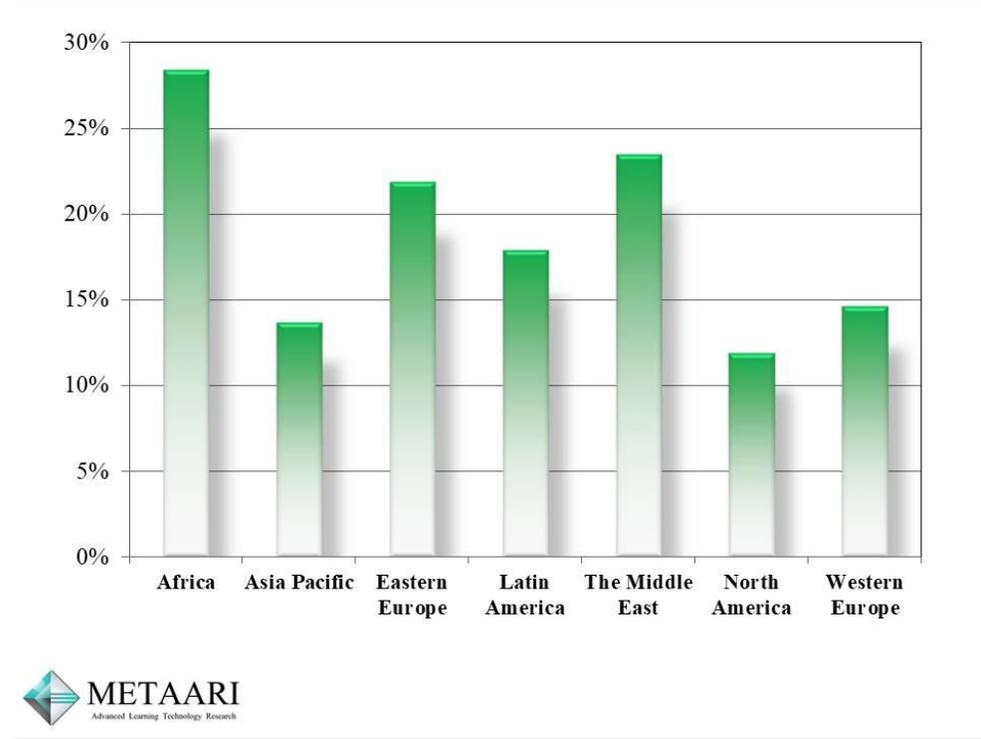
Number of Countries Analyzed in Each Region	Countries Analyzed in this Report by Region
30 Countries in Africa	Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Chad, Côte d'Ivoire (The Ivory Coast), the Democratic Republic of Congo (DRC), Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mali, Mauritania, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Tunisia, Uganda, Zambia, and Zimbabwe
21 Countries in Asia Pacific	Australia, Bangladesh, Cambodia, China (including Hong Kong and Macao), India, Indonesia, Japan, Laos, Malaysia, Mongolia, Myanmar (Burma), Nepal, New Zealand, Pakistan, the Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, and Vietnam
15 Countries in Eastern Europe	Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Georgia, Kazakhstan, Kyrgyzstan, Moldova, the Russian Federation, Serbia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.
18 Countries in Latin America	Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay, and Venezuela (<i>Metaari has suspended analyzing Venezuela during the current financial crisis in that country.</i>)
12 Countries in the Middle East	Bahrain, Egypt, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Turkey, the United Arab Emirates (UAE), and Yemen
2 Countries in North America	Canada and the United States
24 Countries in Western Europe	Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Spain, Sweden, Switzerland, and the United Kingdom

This report provides five-year forecasts for Mixed Reality Learning products for seven regions: Africa, Asia Pacific, Eastern Europe, Latin America, the Middle East, North America, and Western Europe.

The forecasts for each region are for all countries in that region combined. While country-specific revenues are not provided in this report, each regional section identifies the top buying countries for that region.

Africa has the highest growth rate for Mixed Reality Learning at 28.4%, followed by the Middle East and Eastern Europe at 23.5% and 21.9%, respectively. These are high growth regions, but the revenues are relatively low so far. This will change over the forecast period and revenues for Mixed Reality Learning will more than triple in Africa and more than double in the Middle East and Eastern Europe.

Figure 3 - 2018-2023 Global Five-year Global Growth Rates for Mixed Reality Learning Products by Seven Regions



Latin America has a five-year compound annual growth rate of 17.9% and Western Europe has a growth rate of 14.6%. Revenues will more than double in Latin America and nearly double in Western Europe over the forecast period.

Asia Pacific and North America have what appear to be modest growth rates of 13.7% and 11.9%, respectively. Both are rapidly maturing markets with a high demand for Mixed Reality Learning products. Revenues for Mixed Reality Learning products are heavily concentrated in these two regions throughout the forecast period.

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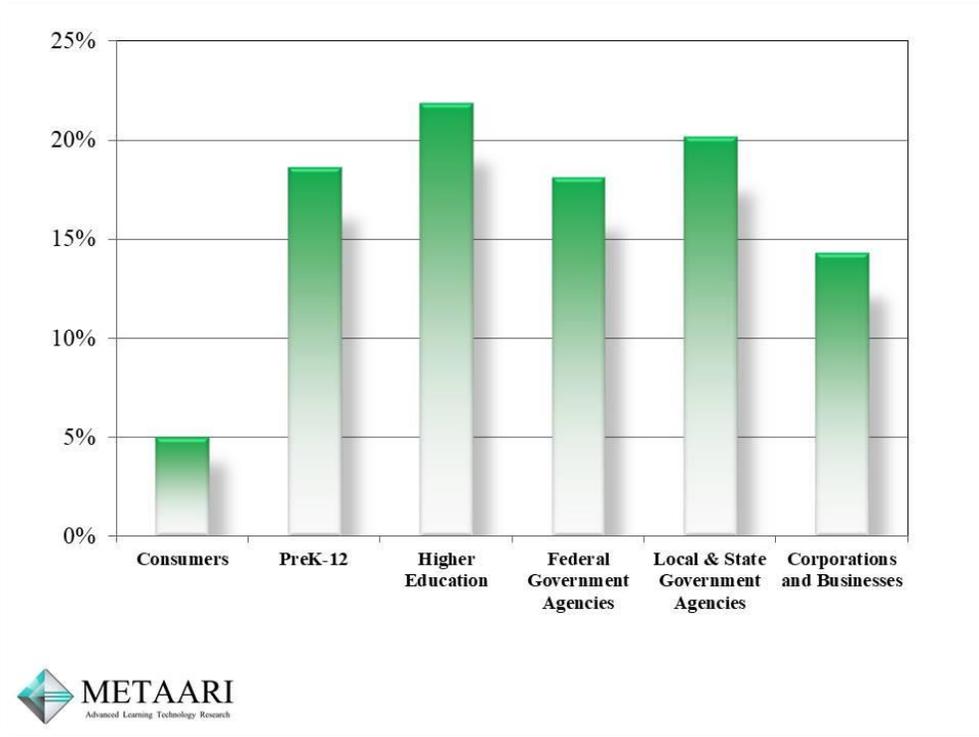
In the 2018 market, Asia Pacific and North America combined accounted for 53% of all global revenues generated by the sales of Mixed Reality Learning products. By 2023, these two regions combined will still account for 46% of all worldwide revenues.

Who are the Buyers?

There are six buying segments identified in this report: consumers, PreK-12 schools, tertiary & higher education institutions, federal government agencies, local/state/provincial/prefecture government agencies, and corporations & businesses.

Figure 4 - 2018-2023 Global Five-year Growth Rates for Mixed Reality Learning Products by Six Buyer Segments

The revenues for Mixed Reality education and training products will nearly triple in the higher education segment over the forecast period.



Revenues for Mixed Reality Learning products will more than double in four of the six buying segments analyzed in this report. The consumer segment has the lowest growth rate at 5.0%. Ironically, this is not due to the lack of demand but rather due to the mass adoption over the forecast period.

As consumers across the planet flock to Mixed Reality Learning products, prices will continue decline. By 2023, the consumer Mixed

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Reality Learning market will essentially be a commodity market; volume sales will be very high, but unit prices will decline. In a commodity market, suppliers tend to compete on price. This is already occurring for AR products like augmented early childhood learning experiences.

Consumers only buy content and they generally do not buy services or tools. This will change over the forecast period due to the rollout of very fast 5G mobile networks across the globe. Real-time VR-based tutoring will be possible over headsets that use mobile devices. 5G has almost no latency; a virtual online class in 5G allows multiple users to interact with each other in real time.

In February 2018, SK Telecom demonstrated their Oksusu Social VR platform that runs on 5G networks and allows full-size holographic images of people collaborating in VR in real time. The company claims that "hologram AI offers the opportunity for mankind to have a completely new mobile communications experience." The company also demonstrated their new AI-based holographic chatbot that displays a conversational avatar AI in a small desktop cylinder.

South Korea's KT and Verizon demoed the first 5G holographic phone call in April 2017 in which a Verizon employee in the US appeared as a hologram on a monitor at KT headquarters. KT is working on the holographic call as part of a set of 5G-based immersive media services that also include 360-degree Live VR. All three carriers now see holographic services as an integral component of next-generation value-added services (VAS).

The buying behavior in each of the six segments is different, yet there are similarities across segments. Both government agencies buy Mixed Reality Learning products to train military personnel, public safety employees, first responders, and healthcare workers.

Government and corporate buyers use tools and platforms to build their own content. They also buy custom development services for custom industrial machinery and military equipment repair and maintenance content.

Revenues in the higher education segment are still heavily concentrated in the healthcare training and education programs; these programs utilize a growing amount of advanced VR-based medical training products. The use of Mixed Reality Learning is now spreading to other STEM programs in the segment.

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The global buyer segments with the highest growth rates for Mixed Reality Learning products are the higher education segments followed by the local and state government segments.

The growth rate in the PreK-12 segment is 18.6%. VR-based educational experiences like Google's Cardboard Expeditions are quite popular in many countries in the world. Third-party commercial education publishers (like Pearson and Houghton Mifflin Harcourt) are now creating packaged content for the Expeditions platform.

There are dozens of developers selling apps for the Cardboard platform. In March 2017, Google announced that they had shipped over ten million of the headsets since the launch in 2014.

Google announced their "Create You Own" initiative in January 2018 as part of their Pioneer Program designed to encourage students and teachers create AR content. The programs include an app to create custom Google VR Expeditions using a 360-degree camera. Google will loan schools a 360 camera during the beta period. ***They also have a new initiative for schools called Expeditions AR and they are expanding their offerings into AR.***

One popular VR product designed for the PreK-12 segment is developed by US-based Nearpod. The company reports that "more than 10,000 U.S. schools in hundreds of districts use Nearpod, as do many schools overseas. That means one in 10 U.S. schools have already adopted Nearpod's virtual reality into their curriculum." Nearpod has obtained \$30.2 million in funding since they launched in 2012.

The growth rate in the federal government agencies across the globe is 18.1% and revenues for Mixed Reality Learning products will more than double over the forecast period.

The revenues are concentrated in a range of simulation, AR, and VR products designed for the military and space agencies. Countries with nationalized healthcare systems are now buying VR-based healthcare education and training product for medical personnel.

The growth rate in the corporate segments across the planet is 14.3%. While this might appear modest in comparison to the higher growth rates in the other organizational buying segments, in terms of revenues, ***corporations are the top buyers for Mixed Reality Learning by a wide margin.*** This will hold throughout the forecast period, although federal government agencies will begin to achieve spending parity with corporations in the 2023 timeframe.

The demand in the corporate segment is being driven by the uptake of real time AR-based decision support products in the industrial verticals. Corporations are the top buyers of custom development services and tools/platforms. That said, many companies have internal development

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groups and they buy the tools and platforms to develop their own content.

Yet, corporations are migrating to VR-based products as well. In July 2017, Volkswagen announced a partnership with a German company called Innoactive to develop VR modules to train over 10,000 production and logistics employees using 30 VR experiences created by Innoactive.

Volkswagen reported in the press that they would "empower employees to use VR to transfer knowledge and improve workflows by making VR headsets available for order throughout the Group." They launched their Digital Reality Hub to host the VR training content in mid-2017.

In December 2017, DHL (the world's largest logistics company) announced a deal with Facebook's Oculus and UK-based VR developer Immerse to build what they call a "virtual learning world" to be used to train *over 100,000 employees across the planet*, making it the world's largest VR training deployment to date.

"The announcement is an important one, as it signifies that one of the world's largest corporations is making a commitment to put VR training right in the middle of their learning programs." DHL is rolling out the new VR content as an integral part of their global Certified International Specialist (CIS) program.

There are dozens of other large corporations moving to VR-based training and they are identified in the demand-side section. The suppliers that are creating the solutions are also identified.

What are They Buying?

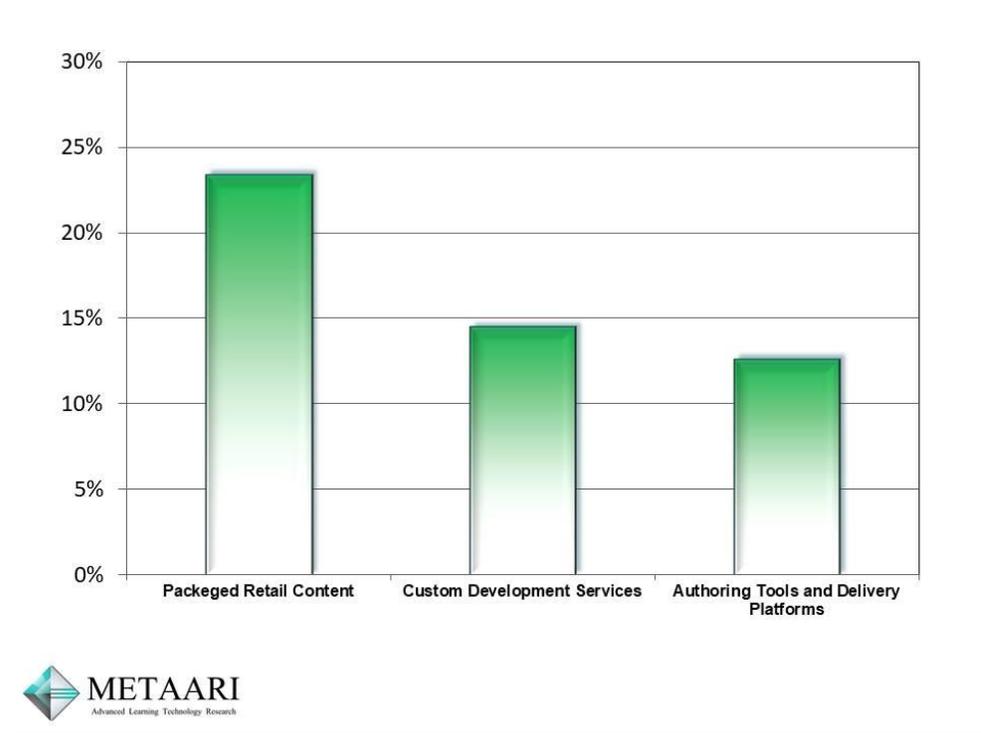
There are three types of Mixed Reality Learning products analyzed in this report: packaged retail content (apps and experiences), custom content development services, and authoring tools & delivery platforms.

Packaged content is further broken out by eight content types providing suppliers with visibility into specific revenue opportunities. Packaged retail content has the highest growth rate at a robust 23.4% and revenues will nearly triple over the forecast period.

A major catalyst enabling packaged content suppliers to get products to market rapidly is the growing number of Mixed Reality Learning marketplaces that sell premade packaged 3D educational objects and animations.

This allows third-party suppliers to "assemble" cost-effective Mixed Reality Learning experiences relatively quickly. Over twenty companies that operate marketplaces that sell premade learning models and experiences are identified in the supply-side section of this report.

Figure 5 - 2018-2023 Global Five-year Growth Rates for Mixed Reality Learning Products by Three Product Categories



Revenues will more than triple over the forecast period for four of the eight Mixed Reality Learning packaged retail content categories.

This report breaks out the packaged retail content revenues for Mixed Reality Learning by eight content categories:

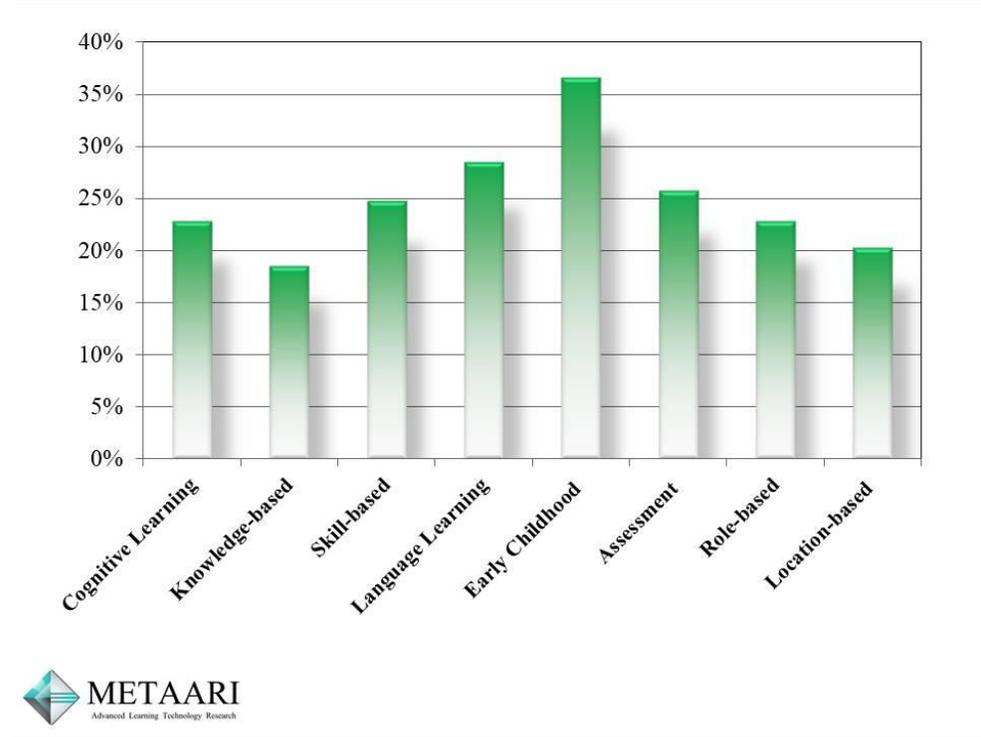
- Cognitive Learning
- Knowledge-based
- Skill-based
- Language Learning
- Early Childhood Learning
- Performance Assessment
- Role-based
- Location-based

All these content types have five-year compound annual growth rates (CAGRs) over 18% and revenues for all of these products will more than double for each of the eight products over the forecast period. Revenues

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will triple for two for two of the eight packaged retail content categories analyzed in this report.

Figure 6 - 2018-2023 Global Growth Rates for Eight Mixed Reality Learning Packaged Content Types (in US\$ Millions)



In general, particular categories of packaged retail Mixed Reality experiences are better suited to either augmented reality or virtual reality. An analysis is provided in the supply-side section.

Mixed Reality Learning content designed for early childhood learning has the highest growth rate at a breathtaking 36.7%, yet it has the lowest revenues in the 2018 market. Mixed Reality language learning has a growth rate of 28.5%, but has the second-lowest revenues. ***High growth rates do not directly correlate to high revenues and are usually found in new product types with nascent current revenues. In contrast, products with lower growth rates are often mature products with very high revenues.***

Mixed Reality language learning apps are very new on the market; they are proving to be quite effective at achieving fluency. As 5G networks roll out across the planet, it is likely that Metaari will revise our forecasts upwards. The companies that sell these new products and the features of their products are analyzed in the supply-side section of this report.

Skill-based Mixed Reality Learning has a 24.8% growth rate and revenues will more than triple over the forecast period. VR-based

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performance assessment products are new types of Mixed Reality Learning and have a growth rate at 24.3%.

Location-based Mixed Reality Learning has a high growth rate of 20.3% driven by the demand for Mixed Reality experiences for tourism and travel. Mixed Reality has proven to be an ideal medium for these experiences.

The growth rate for custom Mixed Reality Learning development services is 14.5% and revenues will nearly double over the forecast period. In the 2018 market, revenues are heavily concentrated in four sectors: healthcare, the industrial verticals, government agencies, and the tourism and travel segments. The demand in each sector is analyzed in detail in the supply-side section of this report.

There is cottage industry of custom developers that create location-based Mixed Reality Learning experiences. This is a significant revenue opportunity for custom developers that specialize in travel and tourism experiences. These suppliers and the venues they serve are identified in this report.

Mixed Reality Learning authoring tools and delivery platforms have a healthy growth rate of 12.6%. These products used to be prohibitively expensive until quite recently. A flood of new Mixed Reality Learning tools and platforms continue to come on the market as the demand grows in the organizational buying segments. They are quite unique being designed from the ground up to author and deliver training and education *experiences* as opposed to courses.

The majority of Mixed Reality Learning tools on the market in 2018 were new sophisticated tools designed to develop AR-based industrial/military decision and performance support content, VR-based healthcare training, and VR-based travel and tourism experiences. There are over fifty suppliers identified in this report that sell these tools. The new VR-based healthcare training tools and platforms are quite advanced and several can import patient-specific medical digital imagery in real time.

These tools are proving to be dramatically effective at lowering training costs, increasing productivity, reducing errors, and decreasing the time it takes to complete tasks; essentially a significant return on investment (ROI). This is a compelling value proposition and one of the major variables directly correlated to the high demand. The ROI is quantified in

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This report only provides forecasts for Mixed Reality tools that are designed to create learning, training, and performance support. It does not include revenues for general-purpose MR tools and platforms.

the demand and supply-side sections of this report with several dozen examples that include empirical data on the effectiveness of these products.

Using these tools and platforms saves clients time and money unlike traditional training products like eLearning, print, or classroom training in which so-called "lost productivity costs" are accrued; when a worker is in training, they are not working. A worker in the field accessing augmented decision support in real time *is completing tasks and learning at the same time.*

The forecasts in this report are for products designed specifically for learning, training, education, knowledge transfer, behavior modification (a synonym for learning), and/or performance improvement and excludes revenues generated by general-purpose Mixed Reality apps, tools, and platforms. This report does not include revenues for devices or Mixed Reality peripherals.

Sources of Data on the Global Mixed Reality Learning Market

There are now dozens of portals across the planet that aggregate global news and information on VR and AR including the Virtual Reality Reporter, Next Reality, VRFocus, UploadVR, Haptical, Wareable, VR World, The Virtual Report.biz, Hypergrid Business Review, Digital Bodies, and Road to VR.

Since all the major technology vendors are now developing AR and VR products, a great deal of market information can be garnered from their press releases and financial reports. In particular, the headset vendors report their unit sales; those data are directly correlated to the uptake of AR and VR content.

Investment patterns provide leading indicators for the global learning technology industry. Companies and investors often report annual revenues at the time of funding. Investments made to Mixed Reality Learning companies in the last few years have picked up momentum and the investment patterns are a good source of data on the types of companies attracting funding and the regions where they operate. For example, the Nordic Cluster is a vibrant hub of Mixed Reality Learning development and companies are attracting significant investments.

Best-of-breeds often report their unit sales and for companies with retail pricing, it is a simple matter to calculate their annual revenues. Academic institutions and government agencies usually report the fees they paid custom content developers.

An analysis of the investment activity surrounding Mixed Reality Learning suppliers is included in the analysis of the global catalysts. An analysis of the Nordic Cluster is provided in the Western Europe section of the demand-side analysis.

A good source of information on the VR industry is the Virtual Reality Society. They describe themselves as a "collective that provides research and development for the commercialization of Virtual Reality."

There are now dozens of companies selling augmented performance support platforms for the industrial and VR-based products in the healthcare sectors. New suppliers are entering the market at a steady rate. They routinely announce new client contracts and licensing revenues in their press releases.

There are two major global trade associations for the AR and VR industries: The VR/AR Association and the Augmented Reality for Enterprise Alliance (AREA).

The VR/AR Association (VRARA) is "an international organization designed to foster collaboration between innovative companies and people in the virtual reality and augmented reality ecosystem that helps develop industry standards, connects member organizations, and promotes the services of member companies." There are VRARA chapters all over the world. As of February 2018, there were chapters in 58 cities across the globe including 24 in North America, 20 in Europe, 12 in Asia Pacific, and two in the Middle East. These chapters provide "hyperlocal" information on the AR/VR markets in their areas. In March 2018, VRARA reported that they had grown membership by over 500% in one year and had over 4,000 registered organizations making it the largest ecosystem in the industry.

VRARA had 24 working committees that focus on specific verticals. "These Committees are working on best practices, guidelines, call-to-actions, standards, and projects to further accelerate the market." The committees are comprised of member companies that compete in specific verticals. There are working committees for education, training, healthcare, tourism, aerospace, and architecture/engineering/construction (AEC). Training and education companies make up the majority of these committees. Each committee has a web page with links to companies competing in those verticals. It is a good way to gather competitive intelligence on Mixed Reality Learning in specific verticals

The AREA had 65 company members in early 2018. They have published the world's first standard functional specifications for augmented industrial application and their documentation places a great emphasis on the application of AR for training and real time on-site

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decision support. Their site includes information restricted to members but a wide range of market-related content available to the public.

Another good source of information is the Virtual Reality Venture Capital Alliance (VRVCA). "Formed in 2016, the VRVCA is a close-knit membership comprised of 47 of the top Virtual Reality Investors in the world. We believe that VR is a transformative technology that will revolutionize entire industries. We are working tirelessly to ensure that the VR startups today get the resources they need."

In December 2016, Google, HTC, Oculus, Samsung, Sony, and Acer launched the Global Virtual Reality Association (GVRA). "This group believes in VR's immense global potential and the opportunities ahead – it will change the landscape of education, training, healthcare, and design, among many other areas." The group disseminates regional VR research reports.

There are local and state/provincial organizations that promote AR/VR and they provide local information on the industry.

- China's Shenzhen Municipal Government and Taiwan's HTC, launched the China VR Research Institute "to boost the VR ecosystem in the city. The Beidouwan Virtual Reality Town is being developed in the Guizhou Province backed by the Guian government to develop their own city's VRAR ecosystem. "Each initiative will dedicate funding and resources to researching, developing, and building partnerships to advance training and education using ARVR."
- The Idaho Virtual Reality Council (IVRC) launched in 2016 and has a strong focus on the educational uses of AR and VR. The IVRC is "Idaho's first networking and education council for Idaho's leaders and innovators interested in virtual reality, augmented reality, and mixed reality. The goal of the IVRC is to bring together people, technologies, and companies to create a thriving VR industry. Networking events and educational seminars will help Idaho organizations to learn faster, cooperate on projects, and promote VR in Idaho."

There are country-based sources of information on Mixed Reality. For example, a good source of information on the VR market in Finland is the Finnish Virtual Reality Association (FVRA). FVRA reports that there are over 100 AR and VR companies in Finland. As of January 2018, just

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under thirty of their members were selling Mixed Reality Learning products and services. They are discussed in the Nordic Cluster section of the Western Europe demand-side analysis.

- Pulse on VR is a pan-Canadian consortium that tracks the VR market in the country. "Launched by CFC Media Lab and OMERS Ventures in collaboration with Nordicity, Pulse on VR represents an ongoing snapshot of the Canadian Virtual Reality (VR) ecosystem as it evolves. Pulse on VR also sheds light on VR's market potential. It notes the challenges and opportunities that companies are identifying as they seize the potential of this transformative medium and shape the future of the VR ecosystem." As of February 2018, Pulse had a directory of 281 VR companies listed by province, with links and descriptions of their business focus. The directory also includes 19 US companies.
- Immerse UK is a good source of information on the AR/VR industry in the UK. As of February 2018, there were 123 members of Immerse UK and 29 were training companies or education institutions. Member get access to a funding directory that includes both public and private sources of investment. Immerse UK has an extensive database of AR/VR funding sources in the UK and has tracked the investment patterns since 2016.
- The NZ AR/AR Association (NZVRARA) launched in September 2016. They sell subscription memberships to companies, academic institutions, individuals, and students. By the end of 2017, they had 116 paid memberships and 44 Student Chapter members. The association publishes annual reports in the VR/AR market in New Zealand.

In late 2016, China's Ministry of Industry and Information Technology (MIIT) and Taiwan's HTC, "in partnership with over 170 private companies and research institutions established the Industry of Virtual Reality Alliance (IVRA). The alliance includes many academic laboratories and research centers including the Beijing University of Aeronautics and Astronautics, Beijing Institute of Technology, Columbia University, and Stanford University."