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Immersive technologies: Benefits, timeframes, and obstacles

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Abstract

With the emergence of immersive technologies in many sectors, a general overview and research review of the technology's uses was undertaken to review its benefits in each sector and obstacles it must overcome to achieve mainstream adoption. It has been suggested that the education, healthcare, and entertainment sectors all will benefit from the use of immersive technology soon, and it is important to understand these benefits. As with any emerging technology, privacy concerns, legal risks, and market disruptions are issues. A review of the literature on this topic was performed as well as a detailed analysis of an industry survey a current understanding of immersive technology and its uses.

Keywords: Immersive Technology, Virtual Reality, Augmented Reality, Data Security

Introduction

Immersive technologies are an emerging technology that has yet to break into the mainstream. Virtual Reality (VR) and Augmented Reality (AR) specifically have made strides in the entertainment sector, with many video games utilizing these technologies to provide a more immersive, interactive experience to players. The entertainment sector, however, is not alone in seeing a boom in immersive technology. Immersive technology has its uses in many sectors, specifically the education, healthcare, and manufacturing sectors.

An accessible definition of immersive technology is "Immersive technologies create distinct experiences by merging the physical world with a digital or simulated reality. Augmented reality (AR) and virtual reality (VR) are two principal types of immersive technologies. These technologies share many of the same qualities. However, AR blends computer-generated information onto the user's real environment, while VR uses computer-generated information to provide a full sense of immersion." (Vista Equity Partners Management, 2022).

Immersive technology can provide a more interactive and safer environment for medical students and professionals, expedite product development in manufacturing, and provide a more engaging learning environment for students; however, it still remains an expensive technology to have properly installed in a work or education environment. There are many roadblocks this technology still must overcome to achieve mainstream recognition. Along with the cost, monetization proves to be an ever-growing concern among consumers specifically in the entertainment sector. As with most video games today, apps may include in-app purchases encouraging the user to spend even more money on an already costly product. It is important that the companies and developers behind this emerging technology create a secure product for consumers before it becomes mainstream.

Our research objective was to explore the status of immersive technologies and review its benefits in each sector, the time frame for adoption and obstacles it must overcome to achieve mainstream adoption.

Literature Review

Because of the nature of immersive technologies being an emerging technology, much of the data and research currently available is very recent, with many specific topics of research on the subject. In reviewing the literature, an extensive survey on the subject emerged which warranted a more descriptive look at the data.

Numerous studies have been conducted regarding more specific uses and benefits of immersive technologies. This article will expand on and provide current data on immersive technology's uses in education, entertainment, healthcare, and manufacturing including over the COVID-19 pandemic. Data security and more technical approaches to the obstacles facing immersive technology's mainstream adoption are also major points that warrant discussion. Suh and Prophet (2018) performed a comprehensive review of 54 immersive technologies articles and found and proposed a comprehensive framework for immersive technology use. They also found gains in user performance from immersive technologies.

Beginning with an overview of immersive technology in the healthcare sector, it is clear just how much VR and AR have influenced new medical developments. To quote an article by Bremner et al. (2019), "Within healthcare, immersive technologies have the potential to disrupt every medical specialty and collectively can also be thought of as 'digital therapeutics'. These technologies allow healthcare workers to treat or manage a medical condition more optimally than would be possible in traditional healthcare (Bremner et al., 2019). Virtual Reality, Augmented Reality, and Artificial Intelligence all have their uses within healthcare. As will be shown later, a major use of immersive technology in the healthcare sector is to train new surgeons or doctors. Immersive technology can provide a more cost-effective, engaging, and safe environment for new doctors or surgeons (Bremner et al., 2019). This being an emerging technology even in the healthcare sector a deeper dive into other uses within the sector as well as what may be some of the obstacles for such an intuitive technology to burst into the mainstream of healthcare is warranted. During the COVID-19 pandemic, immersive technology became essential to educate would-be nurses and doctors in a safe environment (Pears et al., 2020).

Immersive technology has broader educational benefits such as immersive teaching environments and interactive models. Virtual classrooms and 3D models have allowed students to be more engaged in musical performances or science classrooms (Pellas et al., 2021). Not only is immersive technology used for involvement in student's classrooms, it is also useful for educational games (Pellas et al., 2021). These games can provide students with a more interactive and engaging learning environment than a traditional classroom. Despite this being a very attractive technology to students and teachers alike, it is still an unaffordable option for many schools.

In the entertainment sector, Wortley(2014) has detailed likely developments in Immersive Technologies and indicates three main areas: attractiveness, accessibility and affordability needed to focus on to succeed in the increasingly competitive environment. Wortley also examines what this will mean in practical terms for a portfolio of technologies which include interfaces, portable devices, sensors, wireless, broadband, 3D, graphics, location-based services, cloud computing and artificial intelligence.

In the manufacturing sector, immersive technology has several collaborative and efficient benefits. Immersive technology can expedite the product design and development process by providing an

environment for all decision makers to easily get together in a virtual space and test designs (Ramalho et al., 2020). AR can also be used in a similar manner to make tasks more efficient by allowing instructions for a task to appear in the user's vision via an augmented reality headset (Ramalho et al., 2020). Malik, Masood, & Bilberg, (2020) explore technological development in virtual reality (VR) for design of human-centered production systems and developed a framework to integrate human-robot simulation with VR

Lastly, a major topic with any emerging technology is data security. Because most of the product offerings are still new, bugs in the code are bound to cause problems (Lebeck et al., 2018). There is a degree of increased vulnerability in these apps specifically. This obviously poses a problem, especially if it is using your mobile device where very sensitive information is kept. Fortunately, there are steps that can be taken to mitigate data breaches and vulnerabilities. Companies, as shown from the results of the analysis later, are working to restrict the amount of data that is collected, and update policies to reflect steps that have been taken.

Overall, immersive technologies have been slowly breaking their way into different industries and sectors. It has yet to achieve mainstream adoption amongst consumers and organizations alike, though they are seeing various improvements and innovations. Our analysis takes this into account and compares responses from developers within different industries and organizations to understand what new developments or improvements are helping push immersive technologies into the mainstream. Our analysis, of the Perkins Coie LLP survey, also considers the responses from developers that point to possible obstacles to mainstream adoption in each sector.

Methodology

After reviewing extensive literature on this subject, Perkins Coie LLP's survey seemed the most comprehensive amount of data on the subject to analyze. The survey consisted of 42 total questions, with the first two being left out of the raw data. "In January and February 2020, 191 professionals completed the 2020 Augmented Reality and Virtual Reality Survey conducted by Perkins Coie LLP, the XR Association, and Boost VC." (Perkins Coie LLP et al., 2020). Respondents indicated they represented an organization best described as an established technology company (47%), followed by a startup (19%), adviser or outside consultant (16%), investor (12%), or policymaker (5%). Of the 42 questions, 14 were chosen to apprise a descriptive analysis on immersive technology. Each question chosen was compared to other questions to yield insights on possible causes for disruption in sectors, new solutions, or which other technologies may allow immersive technology to become mainstream. As indicated by Perkins Coie LLP, it seems there are massive industry booms on the way for immersive technology (Perkins Coie LLP et al., 2020).

The program used to analyze the data from Perkins Coie LLP was IBM's SPSS. After retrieving the raw data from the company in a Microsoft Excel sheet, IBM SPSS was used to turn the raw data into numeric data for descriptive analysis and cross-tabbing. All the data used for this analysis was cross-tabbed, as that was the best option for comparison between questions. Cross-tabbing allowed for insights to be gained from the data and put into an understandable format. Of all the research available about immersive technologies, Perkins Coie LLP's survey was found to be the most comprehensive survey to give proper insights on the uses of this emerging technology.

Results

Our first analyses explored the consumer privacy issues that are inherent in the VR/AR technologies. Each respondent was asked to choose which system they were developing for, the answers of which were

compared to the answers from the question regarding consumer data privacy. (Which of the following legal risks are of concern to your organization in developing immersive technologies or content? (Select all that apply). Overall, it was found that only 40.3% of the respondents found Consumer Privacy/Data Security as a legal risk in the development of immersive technologies (Table 1). Rates of concern were similar across platforms and reflect a concerning trend among VR/AR developers. Less than half see privacy/security as a legal concern. This may mean that the developers overall believe their security and privacy is already in a good place or perhaps more likely, they do not see consumer's privacy as an important issue.

Table 1: Q27Privacy Risk of Concern in Developing Immersive Technologies

		Frequency	Percent	Valid Percent	Cumulative %
Valid	Consumer privacy/data security	77	40.3	100.0	100.0
	Not selected	114	59.7		
Total		191	100.0		

However, when we look at the actual developers, we see more attention to consumer privacy and security (Table 2). Also, when we examine AR and VR platforms, we see that on average both show about the same level of concern for privacy/security (Table 2 Category 58 versus 59%). But those working on individual platforms show large variations ranging from 79% for Spark AR to 36% for Google Tango.

Table 2: Percentage of Specific Platform Developers Who See Privacy/Security as a Legal Risk

% See P/S	Platform	AR/VR	Total Category
60.6%	Apple ARKit	AR	
59.2%	Google ARCore	AR	
36.0%	Google Tango	AR	
52.9%	Magic Leap	AR	
63.3%	Microsoft HoloLens	AR	
52.4%	Windows MR Headsets	AR	
62.5%	ARVR 1	AR	
78.6%	Spark AR	AR	58.2%
43.8%	Google Cardboard	VR	
77.8%	Google Daydream	VR	
70.6%	HTC Vive	VR	
51.5%	Oculus Rift	VR	
63.3%	Oculus Quest	VR	
65.4%	Oculus Go	VR	
60.5%	PlayStation VR	VR	
41.7%	Samsung Gear VR	VR	59.3%

Within this area, we next examined the steps developers involved with consumer data privacy have taken in addressing concerns. The number one step that has been taken is the limiting of the amount of data that is collected, followed by updating policies. Out of the 191 participants in the survey, only 77 chose the 'Consumer privacy/data security' option. Out of these 77, 46 people chose the 'limiting amount of information collected' option and 42 chose the 'updating privacy policies' option. The rest of the options saw no more than 35 responses, with the number falling off quite drastically with some. This makes it clear that developers prefer to limit the amount of information collected and update their privacy policies accordingly.

Another focal point for our analysis was the timeline developers see to possible mainstream adoption of immersive technologies. The table below shows the total values of each option's response. The number of years is displayed in ascending order from under 2 years, 2 years, 2-5 years, 5-8 years, 8-10 years, and finally over 10 years. Out of all respondents, the option that received the most responses, by far, is the '2-5 years' option. This accounted for 71 of 191 total responses, or just over 37% of all immersive technology developers. This option was followed by the '2 years' option, which received 47 out of 191 responses or just under 25%. With these two options standing out over the others, accounting for roughly 62% of the total responses, we can conclude that immersive technology developers see their technology becoming mainstream within 2-5 years.

Table 3 Immersive Technology TimeFrameQ42Mainstream

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	< 2 years	29	15.2	15.2	15.2
	In the next 2 years	47	24.6	24.6	39.8
	In the next 2-5 years	71	37.2	37.2	77.0
	In the next 5-8 years	32	16.8	16.8	93.8
	In the next 8-10 years	11	5.8	5.8	99.6
	> 10 years	1	0.4	0.4	100.0
	Total	191	100.0	100.0	

Next, our analysis focused on the responses to question 40 compared to the findings of the previous analysis. Question 40 lists different new technologies and asks developers what they see aiding in the mainstream adoption of immersive technologies when both are combined. The two most prominent technologies that will provide a boost to immersive technologies are 5G networks and Artificial Intelligence, due to the number of responses each received. Out of the 191 total responses both 5G and Artificial intelligence received over 100 responses, at 119 and 102 respectively. The other technologies offered as options in this question, being Machine Learning, Edge Cloud Computing, and Internet of Things, all received less than 70 responses. Note that 5G networks also are seen as having a more immediate impact on immersive technology mainstreaming with shorter time frames. Five G networks had 45% within 2 years versus 39% for AI (Table 4).

Table 4 Q42 AI and 5G Obstacle to Mainstream Crosstabulation

			Q42Mainstream					Total
			< 2 years	In the next 2 years	In the next 2-5 years	In the next 5-8 years	In the next 8-10 years	
Q40AI	Artificial Intelligence	Count	16	24	39	18	5	102
		% within Q40AI	15.7%	23.5%	38.2%	17.6%	4.9%	100.0%
		Cumulative%	15.7%	39.2%	77.5%	95.1%	100.0%	
Q40 5G	5G	Count	22	32	42	17	6	119
		% within Q40 5G	18.5%	26.9%	35.3%	14.3%	5.0%	100.0%
		Cumulative%	18.5%	45.4%	80.7%	95.0%	100.0%	

Where VR and AR obstacles to mainstream adoption overlap was the next point of interest among the respondents (Table 5). In the comparison, the one major obstacle to mainstream adoption among both technologies is the user experience. This does affect AR technologies more severely (32%), but it also proves a major problem for VR (19%), being the third biggest obstacle according to the responses. VR's biggest obstacle is its content offerings and quality, followed by consumers' and business's reluctance to embrace VR.

Table 5 Q26 Greatest Obstacle AR versus VR

		AR Frequency	Percent	VR Frequency	Percent	AR-VR %
Valid	Consumer and business reluctance to embrace VR	28	14.7	37	19.4	-4.7
	Content offerings (e.g., lack of quality content, amount of content available)	33	17.3	51	26.7	-9.4
	Cost to consumers	14	7.3	21	11	-3.7
	Financing and investment	20	10.5	17	8.9	1.6
	Government oversight	7	3.7	6	3.1	0.6
	Regulation and legal risks	27	14.1	22	11.5	2.6
	User experience (e.g., bulky hardware, technical glitches)	60	31.4	35	18.3	13.1
	Total	189	99	189	99	0
Missing	8	2	1	2	1	0
Total		191	100		100	

The next point of interest for analysis was the ways in which AR may be more popular than VR. Looking at the responses shows that Apple ARKit developers see the cost as being a major reason for the AR market

surpassing the VR market. This is confirmed across all platforms, with the cost and accessibility of AR options being the two most chosen out of any platform. Out of the 191 total responses, 83 chose the 'cost' option. This accounts for roughly 43% of developers that see cost as a major difference between AR and VR. Right behind the cost option, was the accessibility option with 76 responses. That accounts for just under 40% of participants that believe accessibility is another major difference between AR and VR.

Monetization strategies for immersive technologies also emerged as a point of interest. Our analysis looked specifically at which legal concerns developers had when compared to how they are choosing to monetize their VR or AR product. For all monetization strategies, 'product liability' and 'consumer privacy/data security' were the most pressing legal concerns. Of the 191 participants, 76 and 77 chose each option respectively. This accounts for about 40% of developers that see these two as their most pressing legal concerns associated with monetization.

Our respondents as noted in the tables below are developing for a diverse group of application sectors but regardless of sectors they are developing for, they all viewed healthcare as the area with most disruption. 38% of the total respondents chose the healthcare option, which was the most chosen option out of any given content category except for one category. The only exception was companies developing for the music industry who may not be familiar with the breadth of immersive technologies due to a narrower development focus. Just over 48% of respondents that chose the music option also chose the **education** option, while only 40% chose the healthcare option.

Our last focus for analysis was to look more in depth at each of the sectors with possible disruption as mentioned in question 6. The responses to this question were compared to the corresponding question to which sector was being analyzed. Beginning with the healthcare sector, 49 of the 72 people that chose healthcare believe that training simulations for surgeons is an intuitive new solution which may caus disruption within that sector. That accounts for an overwhelming 68% of participants that chose the healthcare option. We then examined commonalities among these disruptions via correlation analysis (Table 6). These results and significance levels are found in Table 6. Disruptions that correlated with simulations for surgeons were Addressing Visual Disorders and Pain Management. This may suggest a common interest area for specific organizations, mainly in visualizations. Those that selected Assisted Surgery (58%) correlated with Studying Diseases like Cancer and Fostering Positive Social Environments for Neurotypical Individuals. A third group that selected Assessing and Addressing Mental Health Conditions correlated with Improvements in Sleep Habits and Fostering Positive Social Environments for Neurotypical Individuals. Overall, because of this analysis we suggest three groups where AR/VR will be important: Alternate reality for training and distraction, Visual Assistance for medical and scientific procedures, and Alternate environments to improve mental health.

Table 6 HealthCare Disruptions Correlations

Correlations

		Q7DisorderN1	Q7SurgeryN1	Q7SimulationN1	Q7MentalHealthN1	Q7PainMgmtN1	Q7SleepHabN1	Q7EmergencyNavN1	Q7DiseasesN1	Q7FosteringN1	Q7OtherN1
Q7DisorderN1	Pearson Correlation	1	.150	.451**	.154	.045	.176	.240*	.200	.335**	-.109
	Sig. (2-tailed)		.210	<.001	.197	.710	.138	.042	.092	.004	.361
	N	72	72	72	72	72	72	72	72	72	72
Q7SurgeryN1	Pearson Correlation	.150	1	-.013	.108	-.125	-.013	.019	.330**	.282*	.106
	Sig. (2-tailed)	.210		.912	.368	.294	.910	.875	.005	.016	.375
	N	72	72	72	72	72	72	72	72	72	72
Q7SimulationN1	Pearson Correlation	.451**	-.013	1	.077	.235*	.002	.096	.008	.207	.081
	Sig. (2-tailed)	<.001	.912		.522	.047	.988	.424	.945	.080	.497
	N	72	72	72	72	72	72	72	72	72	72
Q7MentalHealthN1	Pearson Correlation	.154	.108	.077	1	.029	.316**	.168	.323**	.344**	.145
	Sig. (2-tailed)	.197	.368	.522		.806	.007	.160	.006	.003	.226
	N	72	72	72	72	72	72	72	72	72	72
Q7PainMgmtN1	Pearson Correlation	.045	-.125	.235*	.029	1	.154	.175	.092	.179	.136
	Sig. (2-tailed)	.710	.294	.047	.806		.197	.140	.442	.132	.253
	N	72	72	72	72	72	72	72	72	72	72
Q7SleepHabN1	Pearson Correlation	.176	-.013	.002	.316**	.154	1	.173	.265*	.355**	-.079
	Sig. (2-tailed)	.138	.910	.988	.007	.197		.145	.024	.002	.511
	N	72	72	72	72	72	72	72	72	72	72
Q7EmergencyNavN1	Pearson Correlation	.240*	.019	.096	.168	.175	.173	1	.348**	.325**	-.100
	Sig. (2-tailed)	.042	.875	.424	.160	.140	.145		.003	.005	.402
	N	72	72	72	72	72	72	72	72	72	72
Q7DiseasesN1	Pearson Correlation	.200	.330**	.008	.323**	.092	.265*	.348**	1	.440**	.112
	Sig. (2-tailed)	.092	.005	.945	.006	.442	.024	.003		<.001	.348
	N	72	72	72	72	72	72	72	72	72	72
Q7FosteringN1	Pearson Correlation	.335**	.282*	.207	.344**	.179	.355**	.325**	.440**	1	-.071
	Sig. (2-tailed)	.004	.016	.080	.003	.132	.002	.005	<.001		.553
	N	72	72	72	72	72	72	72	72	72	72
Q7OtherN1	Pearson Correlation	-.109	.106	.081	.145	.136	-.079	-.100	.112	-.071	1
	Sig. (2-tailed)	.361	.375	.497	.226	.253	.511	.402	.348	.553	
	N	72	72	72	72	72	72	72	72	72	72

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Moving on to the manufacturing sector (Table 7), offering real-time remote assistance is the only new solution rising to the top. And a correlation analysis on the results showed that all the possible disruptions were generally independent. Assembly, employee feedback, maintenance, supply management, prototyping, inventory management, and accident prevention all had varying levels of support but only a few were correlation. Accident and prevention, and workforce training were correlated and a natural fit training subsegment. Prototyping, assembly, and maintenance also formed a weak quality subsegment.

Table 7 Manufacturing Disruptions Correlations

Correlations

		Q9AssemblyErrN1	Q9EmpFeedbackN1	Q9MaintenanceN1	Q9SupplyMgmtN1	Q9WorkforceTrainN1	Q9PrototypingN1	Q9InventoryMgmtN1	Q9AccidentPreventN1	Q9OtherN1
Q9AssemblyErrN1	Pearson Correlation	1	-.058	.239	.192	.045	.390*	.123	.082	.b
	Sig. (2-tailed)		.722	.138	.235	.781	.013	.448	.615	.
	N	40	40	40	40	40	40	40	40	40
Q9EmpFeedbackN1	Pearson Correlation	-.058	1	.029	-.290	-.029	.061	-.092	.000	.b
	Sig. (2-tailed)	.722		.858	.069	.859	.711	.570	1.000	.
	N	40	40	40	40	40	40	40	40	40
Q9MaintenanceN1	Pearson Correlation	.239	.029	1	.239	-.008	.323*	-.057	.227	.b
	Sig. (2-tailed)	.138	.858		.138	.963	.042	.728	.159	.
	N	40	40	40	40	40	40	40	40	40
Q9SupplyMgmtN1	Pearson Correlation	.192	-.290	.239	1	-.055	.179	.231	.082	.b
	Sig. (2-tailed)	.235	.069	.138		.734	.269	.152	.615	.
	N	40	40	40	40	40	40	40	40	40
Q9WorkforceTrainN1	Pearson Correlation	.045	-.029	-.008	-.055	1	.037	.195	.347*	.b
	Sig. (2-tailed)	.781	.859	.963	.734		.822	.228	.028	.
	N	40	40	40	40	40	40	40	40	40
Q9PrototypingN1	Pearson Correlation	.390*	.061	.323*	.179	.037	1	.162	.257	.b
	Sig. (2-tailed)	.013	.711	.042	.269	.822		.317	.110	.
	N	40	40	40	40	40	40	40	40	40
Q9InventoryMgmtN1	Pearson Correlation	.123	-.092	-.057	.231	.195	.162	1	.196	.b
	Sig. (2-tailed)	.448	.570	.728	.152	.228	.317		.225	.
	N	40	40	40	40	40	40	40	40	40
Q9AccidentPreventN1	Pearson Correlation	.082	.000	.227	.082	.347*	.257	.196	1	.b
	Sig. (2-tailed)	.615	1.000	.159	.615	.028	.110	.225		.
	N	40	40	40	40	40	40	40	40	40
Q9OtherN1	Pearson Correlation	.b	.b	.b	.b	.b	.b	.b	.b	.b
	Sig. (2-tailed)	.	.	.	.	.	.	.	.	
	N	40	40	40	40	40	40	40	40	40

*. Correlation is significant at the 0.05 level (2-tailed).

b. Cannot be computed because at least one of the variables is constant.

Lastly, the education sector has two new solutions that rise to the top for possible disruption (Table 8). Immersive or interactive teaching experiences and soft skills development seem to rise to the top, with interactive models for learning just behind the two. Of the 191 total participants, only 53 chose the education sector for disruption in the next two years. Of these 53, 35 chose interactive teaching experiences as an intuitive new solution. 30 participants also chose soft skills development. 29 chose interactive models as well. The correlation analysis performed on the disruptions in the education sector show limited group Immersive Teaching and Individualized Instruction are one group we suggest be named Customized Instruction. The other group includes Interactive Modeling and Soft Skills that we suggest be named Improved Skill Education. These two subgroups that do emerge have low correlation. However other disruptions are independent.

Table 8 Education Disruptions Correlations

Correlations

		Q10ImmersiveTeachN1	Q10PastExperienceN1	Q10ExploratoryN1	Q10InteractiveModelN1	Q10FacilitationN1	Q10SoftSkillN1	Q10IndividualizedN1	Q10OtherN1
Q10ImmersiveTeachN1	Pearson Correlation	1	.174	-.014	.148	-.113	.096	.322*	-.193
	Sig. (2-tailed)		.214	.923	.290	.422	.496	.019	.165
	N	53	53	53	53	53	53	53	53
Q10PastExperienceN1	Pearson Correlation	.174	1	-.100	-.116	.215	.087	.104	.171
	Sig. (2-tailed)	.214		.474	.410	.123	.537	.457	.220
	N	53	53	53	53	53	53	53	53
Q10ExploratoryN1	Pearson Correlation	-.014	-.100	1	.134	.011	-.055	.053	-.136
	Sig. (2-tailed)	.923	.474		.337	.936	.698	.704	.331
	N	53	53	53	53	53	53	53	53
Q10InteractiveModelN1	Pearson Correlation	.148	-.116	.134	1	-.057	.274*	.057	-.152
	Sig. (2-tailed)	.290	.410	.337		.686	.047	.687	.276
	N	53	53	53	53	53	53	53	53
Q10FacilitationN1	Pearson Correlation	-.113	.215	.011	-.057	1	.093	.047	-.083
	Sig. (2-tailed)	.422	.123	.936	.686		.508	.740	.554
	N	53	53	53	53	53	53	53	53
Q10SoftSkillN1	Pearson Correlation	.096	.087	-.055	.274*	.093	1	.112	.121
	Sig. (2-tailed)	.496	.537	.698	.047	.508		.423	.386
	N	53	53	53	53	53	53	53	53
Q10IndividualizedN1	Pearson Correlation	.322*	.104	.053	.057	.047	.112	1	-.095
	Sig. (2-tailed)	.019	.457	.704	.687	.740	.423		.497
	N	53	53	53	53	53	53	53	53
Q10OtherN1	Pearson Correlation	-.193	.171	-.136	-.152	-.083	.121	-.095	1
	Sig. (2-tailed)	.165	.220	.331	.276	.554	.386	.497	
	N	53	53	53	53	53	53	53	53

*. Correlation is significant at the 0.05 level (2-tailed).

Discussion

The ‘consumer privacy/data security’ question is interestingly posed as a legal risk. This could mean that the Samsung Gear and Google Tango developers mentioned previously are much more confident in their current measures to secure consumers’ data, thus making it not pose a great legal risk to them or their organization. The other platforms that were included, while they did not overwhelmingly show a positive response towards consumer data security, had a more even distribution of responses for the ‘consumer privacy/data security’ option. Each of the developer’s responses regarding which platform they were creating content for were also compared to their timeline of mainstream adoption, which shows roughly when the participants expect a mainstream adoption of immersive technology ranging from under 2 years to over 10 years. These outliers in Samsung Gear and Google Tango did not deviate from the 2 and 2-5 year options regarding mainstream adoption, which does not leave them with much time to really improve their data protection systems. If these developers that are not concerned with consumer data privacy also see immersive technology becoming mainstream in the next 2-5 years, that would mean they either have good protections in place already or they are not developing software that actively tracks consumer data.

The new technologies assisting immersive technology were also of great interest, especially when compared to the timeline of mainstream adoption. With faster mobile networks on the rise in 5G, content and services will be made much more available to a wider audience. Many virtual reality and augmented reality pieces of software involve using your mobile device as either a hub for the services associated with immersive technologies, or as the device to run the software. Artificial Intelligence will also go a long way in improving immersive technology systems, being an emerging technology itself. With so many developers choosing these options, it could indicate many crossovers between immersive technology companies and 5G or Artificial Intelligence companies. This could lead to some much-needed innovation among all technologies involved.

With data security becoming increasingly important in the world of technology, the findings from the analysis of the consumer data question may come as a surprise. As stated earlier, the question poses consumer data security as a legal risk. Developers may not be so concerned with getting in legal trouble over issues with consumer data, because they have systems in place that serve to protect the data well enough. With the options chosen for which steps developers have taken in addressing privacy concerns as well, it seems developers are trying to reduce the amount of information that is collected as to prevent any critical personal information or data from being stolen. The privacy policy updates are not unexpected, especially with the changes most developers seem to be making regarding the collecting of data. The General Data Protection Regulation in Europe also pushed many services to update their privacy policies to further secure the data of consumers. With data security becoming an ever more pressing political issue, more companies and services are bound to continue to limit data collected and update policies to reflect that. The focus going forward for developers seems to be to give the consumer more control over their data, and limit what is collected in the first place.

The obstacles to mainstream adoption are as expected. VR technology, specifically in the entertainment sector, has always been seen as a more novel product. There is a constant demand for larger productions and higher quality, which is just not sustainable for immersive technologies at large in their current state. AR has always been more desirable in the entertainment scene, with it becoming increasingly popular on mobile devices. Despite this, it seems the user experience is still not adequate for most users to fully embrace the technology. According to the data, developers of AR technologies see much room for improvement with the user experience having placed it at the top of the list among them. The entertainment sector is not the only sector suffering from these obstacles, however. With this much emphasis placed on these specific obstacles, it must have effects on other sectors such as education or healthcare. This could possibly account for why immersive technologies are still very slowly developing in those sectors. The risks associated with faulty technology in the healthcare sector have dire consequences, making them a less desirable option. There also may not be as much meaningful content for the education sector, as well as the technology being difficult for new users.

Unsurprisingly, cost and accessibility come to the forefront of ways in which AR is more popular than VR. Across the board, when compared to question 3, each platform placed cost as the number one difference between AR and VR. When looking specifically at entertainment products, VR technology is very expensive compared to AR. An Oculus Rift S, one of the platforms mentioned in this survey, costs about 400 USD. Adding that to the amount for a computer capable of running video games for the Oculus Rift S makes it nearly unaffordable, or at least unnecessarily expensive, for an average person. On top of the cost, there just are not enough compelling services or games to justify the price for most people. AR, on the other hand, is much more affordable. Most AR services or games just make use of your mobile device, with some games or services being free to play. This makes AR much more attractive to the average person, at least in the entertainment sector. For sectors such as education and healthcare, immersive technologies serve a different purpose and have different requirements to meet. In education, AR might be more attractive specifically to schools because of the lower cost associated with it. Healthcare might not have as many uses for AR technologies, however, with immersive technologies being used to train surgeons. VR would serve a better purpose for this sector, being a more interactive technology than AR.

The monetization issues with immersive technologies are still a relatively new area for many tech companies that may see their products having unforeseen issues. Specifically, regarding in-app purchases, the product may fail to meet the expectations of the consumers who may feel it was a cheap cash grab for the company developing it. With most online games today offering in-app purchases as a form of monetization, and largely over-monetizing some apps or games, it is not hard to see some products with only profits in mind. There was, however one outlier in this trend. Developers or companies who monetize purely through the sale of products, subscriptions, or games see consumer data privacy as their most pressing legal concern. This could be due to the products, services, or games in question, leaving a lot of

room for data collection using said items or services.

Interestingly, with the music category seeing the most disruption in the education sector, music education may be seeing several improvements using immersive technology. Just looking at entertainment products alone in immersive technologies, there are many "Rhythm games" or video games in the music genre, that make use of VR headsets to provide a more interactive experience. Clearly, the education sector and the entertainment sector overlap when it comes to music.

Training simulations for surgeons also seem to be a very promising technology that will undoubtedly lead to disruption within the healthcare sector. This could also be telling of possible content and product offerings for the healthcare sector soon. With the dangerous environments doctors and surgeons must work in, immersive technology may provide a barrier of protection to the doctor or surgeon undertaking an operation. In the manufacturing sector, while the real-time assistance is a major boom, several solutions may lead to disruption in that sector. The education sector's new solutions also make an easy case for disruption. Much of the content offerings that will serve the purpose of education will involve immersive learning environments for students to increase their engagement with the material they are learning. Each new solution is certainly very promising for disruption in their respective spaces, with interactive learning experiences becoming more common and engaging for students than just sitting in a class with their textbooks.

Conclusion

Through this analysis, contributions have been made. Most developers interestingly do not see consumer data privacy as a pressing legal risk, prompting questions regarding the integrity of consumer's data and the systems that secure it. Developers also see technologies such as 5G networks and Artificial intelligence as possibly helping to push immersive technologies into mainstream. Specifically with mobile devices, more consumers will have access to faster networks to be able to use immersive technology software on the go. With AR technologies being more affordable and accessible than VR, more software and services will continue to be made for mobile devices that can support it. This is projected to lead to a major boom for immersive technologies in the mobile market. The healthcare and education sectors will also see vast improvements in immersive learning environments, interactive 3D models, and training simulations for surgeons, among other new solutions. Our research objective was to explore the status of immersive technologies and review its benefits in each sector, the time frame for adoption and obstacles it must overcome to achieve mainstream adoption. Our results contribute to the literature by reviewing the time for each AR/VR technology, reviewing the projected barriers that need to be overcome before adoption and detail the benefits which are seem for each major sectors including joint benefits. Also, we have determined key differences in AR and VR adoption.

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Appendix A: Selected Survey Questions (Source: Perkins Coie LLP)

3. Which platform(s) are you currently developing for? (Select all that apply)

4. If your organization is creating content for immersive technologies, what type of content are you currently developing? (Select all that apply)

6. In which sectors (outside of the gaming and entertainment space) do you expect to see the most disruption by immersive technologies in the next 12 months?
7. In the healthcare sector, which of the following new applications/solutions can we expect immersive technologies to offer in the next 2 years? (Select all that apply)

9. In the manufacturing sector, which of the following new applications/solutions can we expect immersive technologies to offer in the next 2 years? (Select all that apply)

10. In the education sector, which of the following new applications/solutions can we expect immersive technologies to offer in the next 2 years? (Select all that apply)

25. How are you currently monetizing, - or how do you intend to monetize - immersive technology products or services? (Select all that apply)

26. A – B

    a. What is the biggest obstacle to mass adoption of AR and VR technologies? Select one for each technology.: AR

    b. What is the biggest obstacle to mass adoption of AR and VR technologies? Select one for each technology.: VR

27. Which of the following legal risks are of concern to your organization in developing immersive technologies or content? (Select all that apply)

30. What steps has your organization taken to address privacy and data security concerns with immersive technologies? (Select all that apply)

35. Which of the following factors are most responsible in terms of the AR market surpassing VR market? (Select all that apply)

40. Which of the following technologies, when combined with immersive technologies, will allow immersive technologies to reach mainstream adoption in businesses in the next 5 years?

42. In your opinion, when will the adoption of immersive technologies become mainstream among consumers?