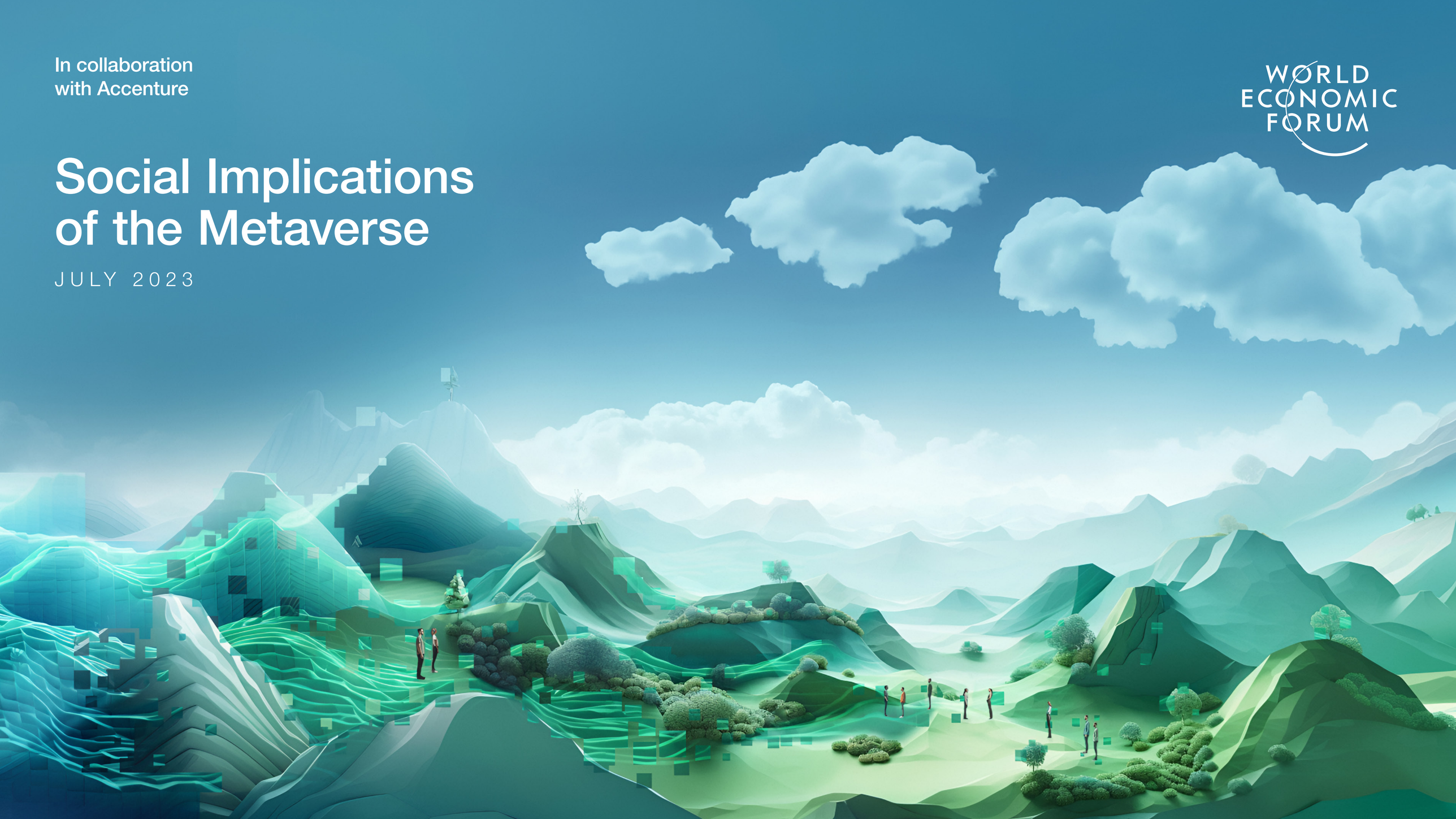
In collaboration with Accenture

WORLD ECONOMIC FORUM

Social Implications of the Metaverse

JULY 2023



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Foreword

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The metaverse, which is a term for the next iteration of the internet, continues to garner research, development and investment interest around the world. Recent findings from Accenture indicate that the projected value of the metaverse is expected to reach $1 trillion in the next three years, suggesting that the metaverse is already experiencing wide adoption. Furthermore, recent developments in generative AI will accelerate metaverse creation and growth, with the metaverse, in turn, providing a way for AI to reach consumers. While AI and metaverse announcements may compete for media attention, they are, in fact, partners in this digital evolution.

The need to cultivate international dialogue and develop directional guidance is now more relevant than ever. The previous era of technology taught us that while innovation can be a powerful force for good, it can also exacerbate existing problems and create new ones. Building upon the lessons learned from the development of the early internet, the World Economic Forum convenes thought leaders from the public and private sectors to collaboratively develop insights, strategies and frameworks to help ensure that the metaverse contributes to economic and social progress while protecting individual rights.

This paper is a continuation of the World Economic Forum's Defining and Building the Metaverse Initiative. In collaboration with Accenture, past outputs from this initiative have delved into the concepts of *Interoperability in the Metaverse* and *Demystifying the Consumer Metaverse*.

We are pleased to present this second output from the value creation track: *Social Implications of the Metaverse.* It highlights the potential consequences and new opportunities of metaverse adoption and usage on individuals. These insights should help decision-makers think about technology development from a holistic lens and incentivize outcomes for a thriving and healthy society.

Simultaneously, the governance track of this project has released its second output: *Metaverse Privacy and Safety.* It emphasizes key conversation areas so that the metaverse may be built with human rights, safety and privacy at its core. By presenting these insights, decision-makers are empowered to create a metaverse based on human-first principles that will positively impact individuals and society at large.

Creating a metaverse that is not only economically viable, but also equitable, accessible, inclusive and safe requires consideration of human rights, equality and sustainability. These two publications are based on the inputs of a global, multistakeholder working group of more than 150 experts from academia, civil society, government, technology and business. The lessons from this process are informing global efforts to help realize the benefits, and mitigate the risks, of the metaverse.

Previous report:
Demystifying the Consumer Metaverse

Executive summary

Select the tabs to explore the five dimensions of the report

The transformative power of technology cannot be denied, yet there are both opportunities and challenges in its application. At its core, the impact of technology, and thus the metaverse, is not solely defined by its capabilities but rather by collective behaviours, attitudes and approaches to its implementation. With the potential for significant disruption across industries, it is important to consider the implications of the metaverse on individual and collective well-being.

The private and public sectors will play a critical role in signalling their demands and intentions with the metaverse through investment, development of metaverse technologies and infrastructure, education and upskilling, as well as policy and regulation that mitigate risks while supporting innovation. Overall, awareness and understanding of the potentialities of technology is the first step in shaping individual and societal responses to it.

This report aims to investigate these potentialities in the context of social implications derived from the use of digital technologies, analyse their potential for exacerbation in the metaverse and explore a non-exhaustive set of new individual and collective opportunities and challenges rooted in metaverse adoption and use. This report does so across the five dimensions laid out in Figure 1.

FIGURE 1

Social value and implications of the metaverse: report overview

- **Access and adoption**
- **Psychological and physical health**
- **Diversity, equity and inclusion**
- **Sustainability**
- **Economic impact and empowerment**

Opportunity

If digital infrastructure is established, the metaverse has the potential to help billions of individuals to access digital identities, education, financial services, healthcare and new economic opportunities.

Challenge

If the establishment of metaverse infrastructure is delayed in certain regions, or metaverse applications do not support regional needs, the digital divide may be exacerbated.

Introduction

In today's world, technology has become an indispensable part of our daily routines, permeating almost every aspect of life. As discussed in the World Economic Forum's previous publication on the consumer metaverse, the metaverse will be built on various technologies and capabilities (see Figure 2), which will increasingly blend physical and the virtual worlds. This seamless integration of physical and virtual realms is anticipated to further elevate technology's presence in our day-to-day activities.

The relationship between society and technology involves the constant interplay between the needs and desires of societies and the capabilities of technological systems. Just as society influences the creation of technological innovation, technology, in return, shapes the world's economic and societal fabric, values and norms.

Ultimately, effectively navigating a dynamic and constantly changing technological, political and socioeconomic environment requires a human-first approach to building a metaverse that prioritizes **social value**. For the purposes of this report, social value is defined as outlined in Figure 3.

While the metaverse's nascent nature makes it difficult to predict an exhaustive list of its implications, some predictions of the metaverse's potential impact can be made by drawing on quantitative and qualitative insights from current technological impact. This report aims to outline a non-exhaustive snapshot of possible positive and negative social implications and aims to guide the creation of a metaverse that prioritizes social value in its design and adoption.

FIGURE 2

Foundational metaverse technologies and capabilities as outlined in the paper *Demystifying the Consumer Metaverse*

- Extended reality (XR)
- Blockchain
- 5G (6G)
- Cloud and edge computing
- Artificial intelligence (AI)
- Digital twins

Source: World Economic Forum, *Demystifying the Consumer Metaverse*, 2023.

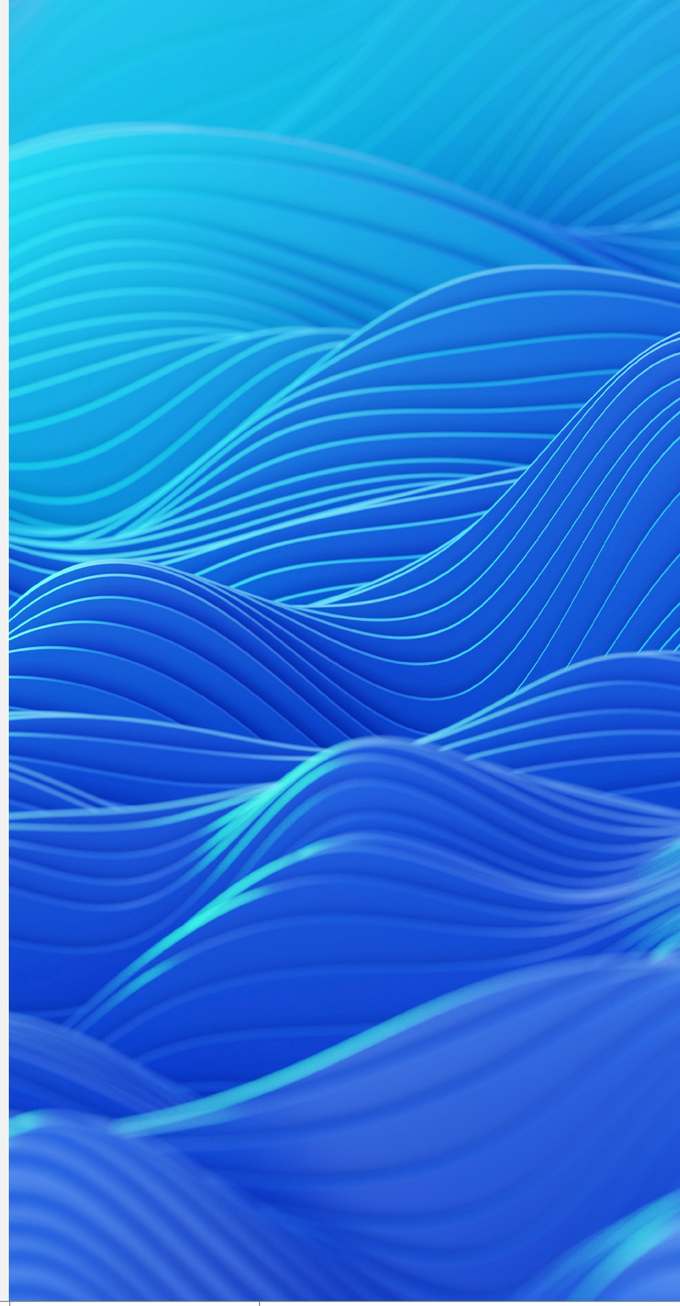
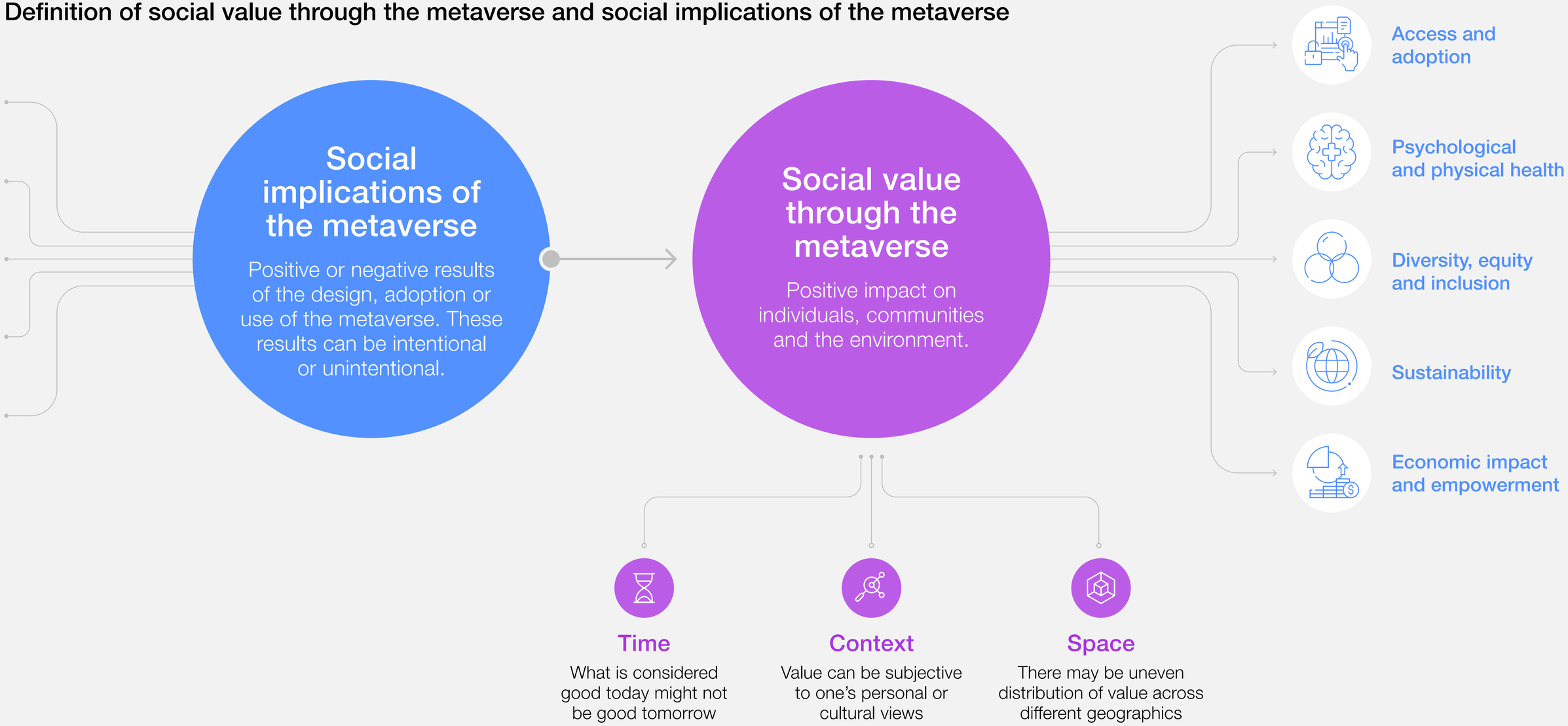


FIGURE 3

Definition of social value through the metaverse and social implications of the metaverse



1 Access and adoption: distribution of value in society

If the necessary digital infrastructure is established across the world, and usage gaps due to affordability and digital literacy challenges are closed, the metaverse has long-term potential to help billions of individuals access digital identities, education, financial services, healthcare and new economic opportunities.

Conversely, if the biggest obstacles to metaverse participation and adoption – connectivity, affordability, usability and digital literacy[1] – become more pronounced, it could lead to increased segregation among different demographics, socioeconomic groups and even nations[2]. This could occur if the establishment of metaverse infrastructure is delayed in certain regions, or metaverse applications do not support low-cost hardware and older operating systems. Nations with the economic capabilities to invest in the growth and development of the metaverse may become the sole beneficiaries – benefiting exponentially more from its evolving socioeconomic opportunities over time.

Nonetheless, even with suitable infrastructure and regulations in place, the metaverse could still prove a significant hurdle for people or communities that have historically been digitally excluded. Their lack of access or experience using prior/existing technologies may need to be addressed to fully adopt and benefit from the offerings of the metaverse. The imperative is to ensure these communities have a voice in contributing to the development of the metaverse – one that has local relevance in design and context – while providing them with the requisite technologies and digital skilling.

Base requirements for accessing the metaverse

The base requirements for using the metaverse may vary depending on the experience and target participants. To promote the inclusion of as many communities and individuals as possible, the elements in Table 1 focus on broad accessibility and affordability to maximize potential for mass adoption.

Some metaverse experiences may require high-specification devices, the latest operating systems, high-speed internet or a VR headset to access the experience. This could exacerbate a class system where some people have better access than others to the best devices, experiences and opportunities.

Certain essential services, such as in the education, financial and healthcare sectors, should be fully functional with only “critical” and “important” elements, and not rely on additional features, to expand accessibility to a wider audience. In contrast, retail, art and entertainment experiences such as shows, concerts or gaming, would be more likely to add in more “variable” features to enhance the user experience.

TABLE 1

Elements of a metaverse minimum viable product (MVP)

Critical	Important	Variable
The metaverse must…	**The metaverse should…**	**The metaverse may, depending on the experience…**
– Be accessible on affordable hardware, including lower specification smartphones and desktops – Be accessible via older operating systems – Have low bandwidth requirements (e.g. 3G accessibility) – Include foundational safety, privacy and security – Be 2D-accessible – Have accessibility features – Have intuitive user onboarding* – Have intuitive user experience.*	– Have a degree of offline functionality – Include collaborative tools and features** – Support multiple languages (including key languages in developing regions) – Allow methods of communication between users (speech, text and/or voice) – Be accessible without legal ID verification – Offer a diverse range of avatars – Have digital identity and wallet standards – Offer interoperability between digital worlds.	– Offer customizable avatars – Offer XR (VR, AR and MR) functionality – Support OpenXR standard – Support a comprehensive range of global languages – Provide experience personalization.
Note: *Intuitive user onboarding and experience refer to the design and implementation of a user interface and interactions that are easy to understand and navigate without requiring extensive instructions or guidance.	**Note:** **Collaborative tools and features in the metaverse refer to virtual technologies and platforms that enable multiple users to engage and interact with each other in a shared digital space, promoting collaboration and socialization.	

BOX 1

Token-gated experiences and commerce

Token-gated commerce and applications,[3] which facilitate exclusive access to products, services or experiences through non-fungible tokens (NFTs), could also be a barrier for individuals without the financial resources to afford the required NFT to gain access, or the digital literacy to acquire and store the token. Public and private sector organizations must carefully consider whether it makes sense for them to provide features such as gated access to metaverse experiences. This is especially important when it comes to essential services such as education and healthcare, since users in the metaverse could be restricted from services and experiences based on whether they hold a specific token or digital identity. This should be considered as an additional lens of access and adoption, separate from access to the devices and connectivity itself, and is dependent on the extent to which web3 plays a role in the metaverse.

Access to education

Education mobility (changes in levels of formal education) and social mobility (change in a person's socioeconomic situation) are closely correlated.[4] Thus, the metaverse, through its potential to open new educational and re-skilling opportunities on a global scale, may lead to direct, positive impacts on an individual's or society's future and quality of life.

The metaverse can provide a new opportunity to democratize education on a global scale, with classes enhanced by interactive and AI-assisted features to boost learning efficacy and efficiency. Access to education through immersive, embodied experiences, as opposed to learning abstract ideas, enables students to "become the archaeologist".[5] This can increase exposure to a greater range of experiences that inform job prospects and incentivizes purpose-led education, particularly for users from disadvantaged socioeconomic backgrounds or remote geographies with a more limited range of job inspiration.

CASE STUDY

Metaverse entrepreneurs

Exponential Destiny is an organization focused on training youths from underserved communities to help re-skill them as modern-day "metaverse entrepreneurs", by employing immersive and experiential teaching through VR and AR. It also uses XR technologies, otherwise known as spatial computing, to assist social-impact and cultural organizations (non-governmental organizations and museums) by bringing education, awareness and empathy to their causes in unique simulations.

A new learning environment for digital literacy and skilling

Ironically, the metaverse itself can provide the runway for better digital literacy, digital skilling and education to take advantage of the opportunities of technology in its entirety. The metaverse can provide a new opportunity to onboard participants into the digital sphere and its economies and serve as a training ground for developing digital literacy at scale.

The World Economic Forum's Education 4.0 Alliance[6] (or "Reskilling Revolution") states that the skills of the future should focus on creativity, analytical thinking, digital literacy, AI and collaboration[7] – all skills the metaverse will be well positioned to facilitate teaching on, within its interactive settings. Nvidia chief executive officer Jensen Huang recently stated that the proliferation of new AI tools has already significantly lowered the barrier to entry for learning computer programming.[8]

CASE STUDY

Whose Metaverse?

The Whose Metaverse?[9] learning platform is home to a variety of immersive educational courses for students to build digital skills and co-create in the metaverse. It offers courses on emerging technologies, including metaverse basics, generative AI, NFTs and creativity, and promotes a hybrid model whereby students meet in a physical location, such as a community hub in Harlem, to collaborate, learn and become creators with metaverse and web3 technologies.

This model could be replicated in rural areas and regions with limited connectivity, where the hub acts as a meet-up point for students to develop digital skills together and collaborate with other hubs via the metaverse. This approach can be highly impactful for remote communities and marginalized students, as learning retention via immersive learning is 75% more effective,[10] and students are 275% more confident in applying skills[11] learned in immersive settings when compared to physical classroom study.

Grounds for new identity

There are around 1 billion people worldwide with no legal identity,[12] who therefore cannot open a bank account, get a loan or vote. The majority live in low-income countries, where almost 45% of women and 28% of men lack a legal ID. Ensuring everyone has a legal identity by 2030 is one of the UN's Sustainable Development Goals (SDGs).

The provision of digital identities in the metaverse must be carefully considered by regulators, as well as public and private sector organizations, to ensure those without a legal ID are not excluded from obtaining a digital ID. There are trade-offs to data privacy that must be considered, as well as complications related to cybercrime, financial crime and other abuse that may arise from a user being able to create multiple IDs.[13] An ecosystem of trusted digital identity issuers will be key to ensuring individuals are not excluded from new educational, financial and social opportunities because they cannot obtain a digital ID, while introducing levels of trust to minimize potential for fraud.

The metaverse may offer a new means of providing identities to those who do not currently exist in ID systems and serve as a potential pathway towards inclusive access to educational, financial and other services.

In addition to facilitating provision of unique and immutable identities, blockchain technology, via tokenized digital IDs, represents an opportunity to provide digital property rights and data ownership to the ID holder. This would allow the individual to build up their reputation and benefit socially and economically from the development and achievements of their identity in the metaverse, while maintaining ownership of personal data.

In digital worlds, different experiences may call for different approaches to digital identity. In some applications, such as media and entertainment, anonymous or pseudonymous identities may be suitable, whereas banking, education or work-related experiences may require legal identification. In some metaverse experiences, anonymous identities may remove potential bias or discrimination the individual might otherwise experience because of their real-world identity, such as when applying for jobs, or in workplace/social scenarios.

However, it is important to consider that anonymous identities can increase the risk of malicious behaviour. This risk may be mitigated by promoting a trust network, which allows individuals to request trusted digital IDs and proof exchange protocols to exchange proof of identity in a privacy-preserving way.

Access to healthcare

Health equity is achieved when everyone can attain their full potential for health and well-being.[14] Global organizations including the World Health Organization (WHO) and initiatives such as the World Economic Forum's Global Health Equity Network (GHEN) have promoted health equity as a critical objective, creating a future where human and climate sustainability become a reality. Historically, digital technology has played a key role in improving health equity. Edison Alliance partners have so far brought 90 million people access to digital healthcare services such as remote care, telehealth platforms and telemedicine services. One example is the collaboration between Apollo Hospitals and American Tower Corporation (ATC), which launched five digital dispensaries in rural India to provide 250,000 local individuals with primary, preventive and specialty teleconsultation services.[15]

The metaverse may support a sizable leap in the evolution of these services, enhancing the efficiency of healthcare provision in an immersive, realistic and more personalized medium. AI will further provide real-time diagnoses of illnesses with increased accuracy.

Across the world, low-to-middle and high-income nations still face significant workforce challenges and burdens in the healthcare sector. However, countries with the lowest relative need have the highest number of healthcare workers, while countries with the greatest need have fewer professionals – Africa shoulders over 22% of global disease but has only 3% of health workers.[16] The metaverse could facilitate patient screenings, remote surgeries and digital therapeutics with healthcare specialists from across the world, potentially helping to mitigate a shortage of local specialists.

Lack of connectivity remains a challenge in regions that need modern healthcare services the most. One solution is for governments to establish local hospitals and digital dispensaries in these areas, with internet connectivity and communal hardware devices that can be accessed and used by patients.

2

Psychological and physical health

Psychological health

According to the WHO, “health is a state of physical, mental and social well-being and not merely the absence of disease or infirmity”.[17] The adoption and use of digital technologies has been shown to affect individual and collective health, both positively, through its advancing of capabilities and innovation in healthcare, and negatively, through the emergence of new physical and psychological health risks.[18] Through its immersive and persuasive nature, the metaverse could potentially amplify these effects.

The psychological and physical effects of the metaverse are influenced by factors such as user age, exposure time, type of medium and interaction, individual habits and genetic predisposition. For example, while moderate screen time can positively impact individuals’ well-being, no or too much screen time can cause negative effects.[19,20,21] With an aim to drive discussion, research, collaboration and responsible metaverse design, this report provides a snapshot of potential social value opportunities and challenges, while not aiming to outline an exhaustive overview of the psychological or physical implications of the metaverse. Further longitudinal research that contrasts both positive and negative effects of metaverse use is needed to efficiently prioritize health in the design, use and regulation of the metaverse, and to ensure that individuals can benefit from its potential without being put at risk.

Cognitive function

Digital technologies can enhance human cognition, with research suggesting a complex relationship between technology use and attention, memory and knowledge.[22,23,24] The use of digital media has further been linked to positive learning outcomes, especially when individuals can consume and actively create content.[25] Furthermore, studies suggest that XR can enhance attention[26] and memory.[27] Overall, VR-supported cognitive interventions have been shown to have potential rehabilitative effects in a clinical context, even for individuals with mild cognitive impairments or brain injuries.[28]

Conversely, there is evidence to suggest that the use of digital technology can also have negative effects on cognitive function, including attention problems,[31] heightened attention-deficit symptoms and impaired brain development.[32] Furthermore, research on the effects of technology on younger age groups suggests that technology use can lead to both short-term changes in mood and longer-term changes in brain function.[33] In the context of the metaverse, it is important to note that the immersive and persuasive nature of the medium could potentially amplify both positive and negative effects, for children and adults, particularly if users are spending significant amounts of time in virtual and augmented environments.

> **Technology is not a single unique entity and thus is unlikely to have a single unique effect. One can no more ask, ‘How is technology affecting cognitive development?’ than one can ask, ‘How is food affecting physical development?’ Like with food, the effects of technology will depend critically on what type of technology is consumed, how much of it is consumed, and for how long it is consumed.**
>
> Daphne Bavelier, C. Shawn Green and Matthew W. G. Dye, “Children, wired – for better and for worse”, *Neuron*, September 2010.

CASE STUDY

Virtual reality innovation for cognitive health

UC San Francisco-based Labyrinth VR, a spatial wayfinding game, helps elderly individuals to boost their long-term memory.[29] Moreover, the company Mindmaze enables evidence-based, protocolized therapies for the restoration of motor, cognitive and cardiovascular function, as well as therapies and technologies that enable clinicians to maximize the delivery of motor and cognitive neurorehabilitation.[30]

Stress, anxiety and depression

As the newest iteration of digital transformation, the metaverse could be used as a tool to alleviate symptoms of stress, anxiety and depression, and may offer benefits in both leisure and clinical contexts. The metaverse further enables and encourages social interaction, which could also mitigate symptoms. Academic research indicates that the relationship between technology use and stress, anxiety and depression is mediated by factors such as screen time, type of experience and nature of the digital medium. However, while VR has been proven to alleviate anxiety and depression symptomology in a clinical trial, its therapeutic advantages over traditional therapy are unclear.[34]

CASE STUDY

Immersive VR experiences for stress, anxiety and depression

Evenness, an immersive VR sensory room experience for people with disabilities, has been shown to induce significant improvements in anxiety, depression and sensory processing.[35] Moreover, emerging providers such as BehaVR and XRHealth aim to support individuals on their mental health journey by helping with mental wellness, anxiety regulation, pain management and addiction recovery.

Digital technology use has been shown to have a negative impact on psychological health, with research indicating a link between technology, social media use and heightened levels of stress and anxiety.[36] This phenomenon is especially evident for female teenagers.[37]

Although it is difficult to measure direct effects, studies suggest that excessive technology use can result in decreased sleep quality, social isolation, information overload and decision fatigue, which may be linked to stress, anxiety and depression, particularly through increased rapid task switching and excessive notifications. Through the transition from desktop and phone-based applications into augmented and virtual reality, and thus potentially increased exposure to information, the metaverse could exacerbate these negative effects.

Sensory overload

Sensory overload is the overstimulation of one or more of the body's five senses of touch, sight, hearing, smell and taste. Though sensory overload can affect anyone, it commonly occurs in autistic people and, in some cases, in people with epilepsy, those with post-traumatic stress disorder (PTSD), sensory processing disorder and certain other conditions.[38]

Through its capability of diminished reality (DR), a technological application that allows users to remove elements from their field of view in real-time, the metaverse could allow individuals that are prone to experiencing sensory overload to participate in virtual situations that they might struggle with in the physical world. Removing distractions from an individual's environment, could help them stay focused and engaged, leading to improved productivity and sense of accomplishment.[39] Furthermore, metaverse features, such as gaze-contingent displays are showing potential in lowering sensory overload.[40] However, these features' potential to distort individual or collective perception of reality needs to be considered when harnessing their benefits.

> **Today AR and VR are visually focused technologies and as we delve deeper into immersive technologies becoming a part of our everyday reality, cognitive overload is a real risk**
>
> Helen Papagiannis, Founder, XR goes Pop

On the contrary, research demonstrates that for healthy adults, AR can trigger the level of sensory overload children on the autism spectrum experience.[41] As the metaverse can be visually and auditorily overwhelming, with bright colours, flashing lights and loud noises, its use may lead to sensory overload and thus discomfort, stress, loss of focus, anxiety or fear. Applying either an inclusive design approach or principles of "calm technology" can significantly improve the metaverse experience. These techniques are not only beneficial to users with sensory processing issues, providing them a more positive and comfortable interaction, but they also offer advantages to the majority of users.[42]

BOX 2

The development of haptics in the metaverse

The use and development of haptics in the metaverse is showing increasing potential. Haptic technology has the power to enhance realism, immersion and personalization in the metaverse. By distributing XR experiences across multiple senses, cognitive overload could potentially be reduced.

Body image and disassociation

In the metaverse, individuals can choose to present themselves in any way they wish, elevating their freedom of self-expression and reducing their exposure to social stigma. This can be particularly beneficial for individuals who may not feel comfortable expressing themselves in the physical world (due to societal pressures, for example). People who are represented by avatars that are more attractive than their physical selves report, that their virtual selves are more outgoing, risk-taking (and superficial).[43] Research further highlights, that VR "seems to be able to turn [users'] self-concepts in a positive direction, while fostering self-acceptance, thus allowing them to focus on what they can change within their control, rather than trying to reach unrealistic beauty ideals".[44] From a clinical standpoint, the metaverse may evolve to be a valuable and effective tool to treat body image disturbances, especially through its immersive capabilities.

Contrasting the metaverse's opportunities to improve individuals' body image, the metaverse can have the potential to alter the way individuals relate to and understand their own bodies. Through its immersive nature and by blurring "the line of reality and fantasy", metaverse avatars could trigger overall bodily dissatisfaction[45] and body dysmorphic disorder (BDD),[46] which describe individuals becoming fixated on imagined defects in their appearance. However, a person's physical body and their metaverse avatar representation may often be different, and so, it remains unclear whether the same types of body dysmorphia triggered by traditional social media will also be present in the metaverse. While environments and worlds that are drastically different from the user's physical environment can provide positive effects, long exposure times may further contribute to self-dissociation.[47]

Consequently, if a virtual environment is a completely different world with different social norms or cultural values, the user may feel a sense of disconnection from their own physical identity or sense of self. However, it is yet to be seen how these assumptions hold in virtual worlds in which people can be whoever and whatever they choose.

BOX 3

Gender differences in body dissatisfaction: the impact of realistic avatars

A recent experimental study provides evidence for differing effects on women and men in regard to body dissatisfaction after being represented by a realistic avatar. It highlights, that "the experience of virtual body experience negatively affected the female participants' body size perception and the emotional state about their body (i.e. body dissatisfaction) much stronger in women than in men." – Juyeon Park, "The effect of virtual avatar experience on body image discrepancy, body satisfaction and weight regulation intention", *Cyberpsychology: Journal of Psychosocial Research on Cyberspace*, vol. 12, issue 1, 25 July 2018.

Addiction

A 2019 report by the Organisation for Economic Co-operation and Development (OECD) supports the thesis that digital technologies and thus the internet “[trigger] neurological processes similar to other addictive substances and activities”.[48] In 2018, the WHO added gaming disorder to the 11th revision of their International Classification of Diseases. According to the WHO, “Studies suggest that gaming disorder affects only a small proportion of people who engage in digital or video-gaming activities. However, people who partake in gaming should be alerted to the amount of time they spend on gaming activities, particularly when it is to the exclusion of other daily activities”.[49]

The addictive nature of gaming is further shown to not only be triggered by the enjoyment of gaming itself, but furthermore, microtransactions and especially loot boxes are associated with gaming disorder and gambling disorder.[50] In-world assets, and thus microtransactions, are a vital part of the metaverse as it is seen today. Moreover, virtual reality is proven to distort a user’s sense of time.[51] Consequently, the question arises as to whether the metaverse has the potential to exacerbate the number of individuals with gaming or gambling disorders through exposure time and in-world assets.

BOX 4

Varying susceptibility to addiction in young gamers

A study conducted in 2011 revealed that children and teenagers exhibit varying levels of susceptibility to addiction, as evidenced by the differentiation in the brain region associated with reward processing and motivation between frequent and infrequent gamers. This emphasizes that not all gamers will develop addiction.[52]

Trauma and PTSD

The US Department of Veterans Affairs has been at the forefront of using VR therapy to treat PTSD and companies such as Bravemind VR already train coping mechanisms for anxiety, phobias or PTSD in VR.[53] Combined with physical or virtual in-person therapy, the metaverse offers great opportunities for trauma treatment.[54] However, outside of therapeutic measures, the positive effect of metaverse use on trauma is unknown.

While the metaverse can offer benefits to those experiencing PTSD, it may also trigger PTSD itself. According to the Diagnostic and Statistical Manual of Mental Disorders, “exposure to actual or threatened death, serious injury or sexual violence”[56] are diagnostic criteria for PTSD. Through its partly or fully immersive capabilities, the metaverse can make an experience feel more real than other forms of media. This could create a sense of presence and could mimic a parallel form of threatened death, serious injury or sexual violence. This could pose an especially large risk of trauma to content reviewers for metaverse platforms.

CASE STUDY

Metaverse for PTSD treatment

According to a recent study, examining VR therapeutic effectiveness for Iraq War veterans, out of 20 war veterans who underwent VR treatment, 16 no longer met the diagnostic criteria for PTSD upon completion of the therapy.[55]

Snapshot

Indirect implications of metaverse and AI to psychological health

The metaverse may serve as a tool to enable new means of social connection beyond geographic boundaries or social groups, both online and offline, and may help individuals to improve their interpersonal competence. A 2022 study on AI- and VR-enabled avatar interaction provides evidence that "interpersonal effectiveness can be learned and improved with repeated interactions with an avatar".[57] While AI comes with several risks, its benefit in augmenting human connection, knowledge, innovation and creativity is significant.

Human-like AI avatars: A columnist of the New York Times published a conversation with an AI bot that implied "it would like to be human, had the desire to be destructive and was in love with the person it was chatting with".[58] Potentially exacerbated through the realistic nature of interaction with AI-driven avatars, the metaverse may create a false sense of intimacy or emotional connection between the user and AI. This could potentially lead to emotional attachment and thus, negative psychological effects if the AI avatar is removed or its conversational "baseline" is changed. The potential for emotional manipulation by AI avatars may cause users to feel vulnerable and anxious about their interactions in the metaverse, having a potentially negative impact on psychological health.

"Overtrust" and overreliance on AI: An increased trust in AI avatars may lead to a loss of trust in oneself and an overreliance on AI-driven decision-making. If a person relies heavily on an AI system to make decisions, solve problems or provide recommendations, they may begin to doubt their own abilities to perform those tasks, which may lead to a reduction in self-confidence and motivation to learn new skills and a lack of critical thinking. The persuasive power of the metaverse could further enforce the idea that AI systems are more reliable and accurate than human decision-making.[59] Overall, the metaverse could exacerbate the risks of overtrust in AI. In the context of psychological health, the erosion of critical thinking skills could possibly lead to a decrease in problem-solving abilities and an increased sense of helplessness, powerlessness or depression.

BOX 5

The growing significance of AI in the metaverse

Due to recent advancements, AI's impact on the metaverse will likely become even more significant than previously foreseen, especially through its human-like features and capability to automate content creation at scale.[60] Generative AI[61] is changing the way content is created and the metaverse will change how this content is distributed, experienced and interacted with. While AI's standalone disruptive potential is significant, combined with technologies such as virtual, augmented, mixed or diminished reality its impact may be amplified in the context of the metaverse. However, the exact nature of this impact is difficult to foresee today. Not only is AI expected to change the way humans conduct their professional and private lives, but has intrinsic potential to alter "the human relationship with reason and reality".[62]

Physical health

Linking psychological and physical health

Research has established a strong connection between psychological and physical health, with changes in one domain often influencing the other.[63,64] Consequently, metaverse applications that promote psychological health, such as meditation or stress management tools, could improve physical health outcomes such as lower blood pressure and decreased risk of heart disease.[65]

CASE STUDY:

TRIPP

TRIPP, a wellness platform powered by the metaverse, strives to enhance self-connection and collective well-being by offering fully immersive experiences that revolutionize meditation practices.

However, previously discussed psychological implications such as addiction, social isolation or increased anxiety and stress could indirectly impact physical health, for example, by disrupting sleep patterns or contributing to unhealthy lifestyle habits.

Physical health impacts of VR in a leisure context

When considering further possible negative impacts of the metaverse on physical health, issues such as deteriorating eyesight, poor posture, physical inactivity and resulting obesity are among the most discussed consequences associated with the negative effects of digital technologies on physical well-being. While there is some evidence that VR can cause temporary visual disturbances and discomfort, the long-term effects of using VR glasses or headsets on eyesight are still not fully understood.

> **There have been some studies looking into the effects of short-term use of VR headsets only; these did not reveal a deterioration in eyesight. However, some people do suffer from temporary symptoms such as nausea, dry, irritable eyes, headache or eyestrain[66]**
>
> Ceri Smith-Jaynes, Clinical Editor, Association of Optometrists

CASE STUDY

Metaverse at-home applications for physical health

The metaverse's most discussed "at-home" opportunities to better physical health may be its applications for fitness gamification. OliveX gamifies fitness through AR, social interaction, and play-to-earn experiences, while companies such as FitXR and Supernatural were able to turn surging demand into monthly subscriptions. The application Sense Arena delivers VR training tools to improve mental and cognitive abilities for peak sports performance, used and endorsed by the US National Hockey League and 18-times Grand Slam winner Martina Navratilova.

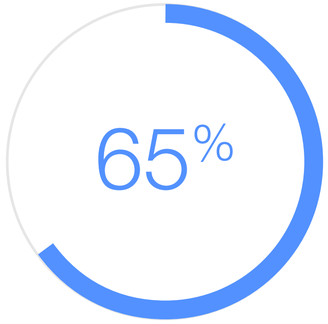
Snapshot

The metaverse's clinical health applications

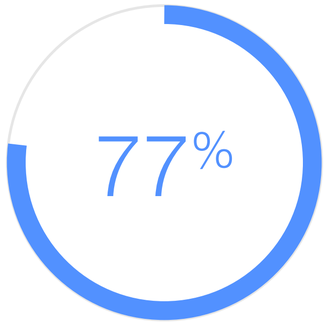
While the numbers (see Figure 4) confirm the validity of the metaverse's wide range of opportunities in the "private" realm, a large social value opportunity may lie in improving access, experience and outcomes of healthcare through improved training, education, therapeutics, diagnostics, delivery and collaboration. XR especially offers great opportunities for physical therapy to help with disabilities or injuries, as well as pain management.[67] Furthermore, VR treatment shows promising results in treating phantom pain in missing limbs and supporting the rehabilitation of motor deficits after a stroke.[68]

FIGURE 4

Consumer interest and potential adoption of the metaverse for health and wellness



of consumers are excited about or actively engaging in metaverse technologies for health and wellness



of consumers are open to use the metaverse to manage their health

Source: Accenture

The following use cases give further insights into practical applications of the metaverse in healthcare.

Surgical training and support: OssoVR, for example, provides VR-based surgical training, which de-risks procedures for patients, claiming to improve surgeon skill transfer by 230%. Other players include MediView, which uses AR-based "x-ray vision" during surgery, and FundamentalVR, which provides a haptic-feedback-based training tool.[69]

Image-guided diagnosis: Furthermore, physical health can be increased through access to intelligent healthcare systems such as MeTAI for the refinement of AI-based medical practice, including medical imaging-guided diagnosis and therapy.[70]

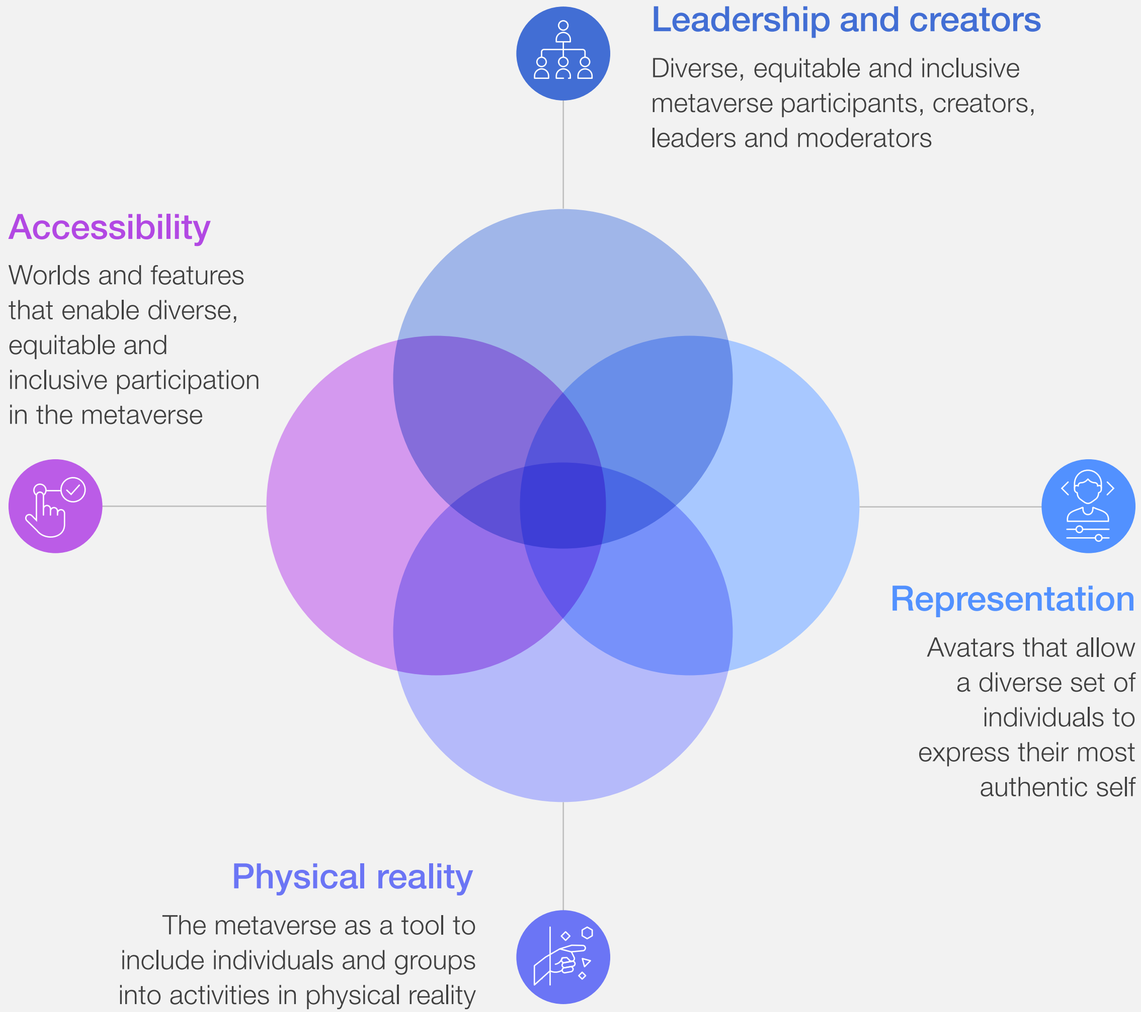
Virtual reality in medical education to teach empathy: A project by the University of New England highlights that by simulating being a patient with age-related diseases in VR, students show increased empathy and understanding of age-related health problems.[71]

3 Diversity, equity and inclusion

As the concept of the metaverse rapidly evolves, it is essential to recognize that diversity is a fact, inclusion is an act and equity is the goal. It is important to move beyond surface-level diversity and towards creating equitable and inclusive spaces that value and uplift underrepresented communities. In the metaverse, diversity, equity and inclusion (DEI) operate on four key layers: 1) diverse leadership, creators and participants, 2) accessibility in software and hardware, 3) representation, and 4) enablement of a more fair and equitable physical reality.

FIGURE 5

Diversity, equity and inclusion metaverse layers



When building metaverse teams and creating hardware, software and experiences, it is crucial to prioritize diversity, equity and inclusion across multiple layers (see Figure 5) and dimensions (see Figure 6) to enable a fairer distribution of social value. Guided by the World Economic Forum's global racial and ethnic equity framework,[72] this chapter aims to explore potential challenges that the metaverse could pose and highlights social value opportunities that support the creation of a diverse, equitable and inclusive physical and virtual reality.

Click on the icons to explore a selection of diversity, equity and inclusion factors to consider in the metaverse

FIGURE 6

Non-exhaustive selection of DEI factors to consider in the metaverse

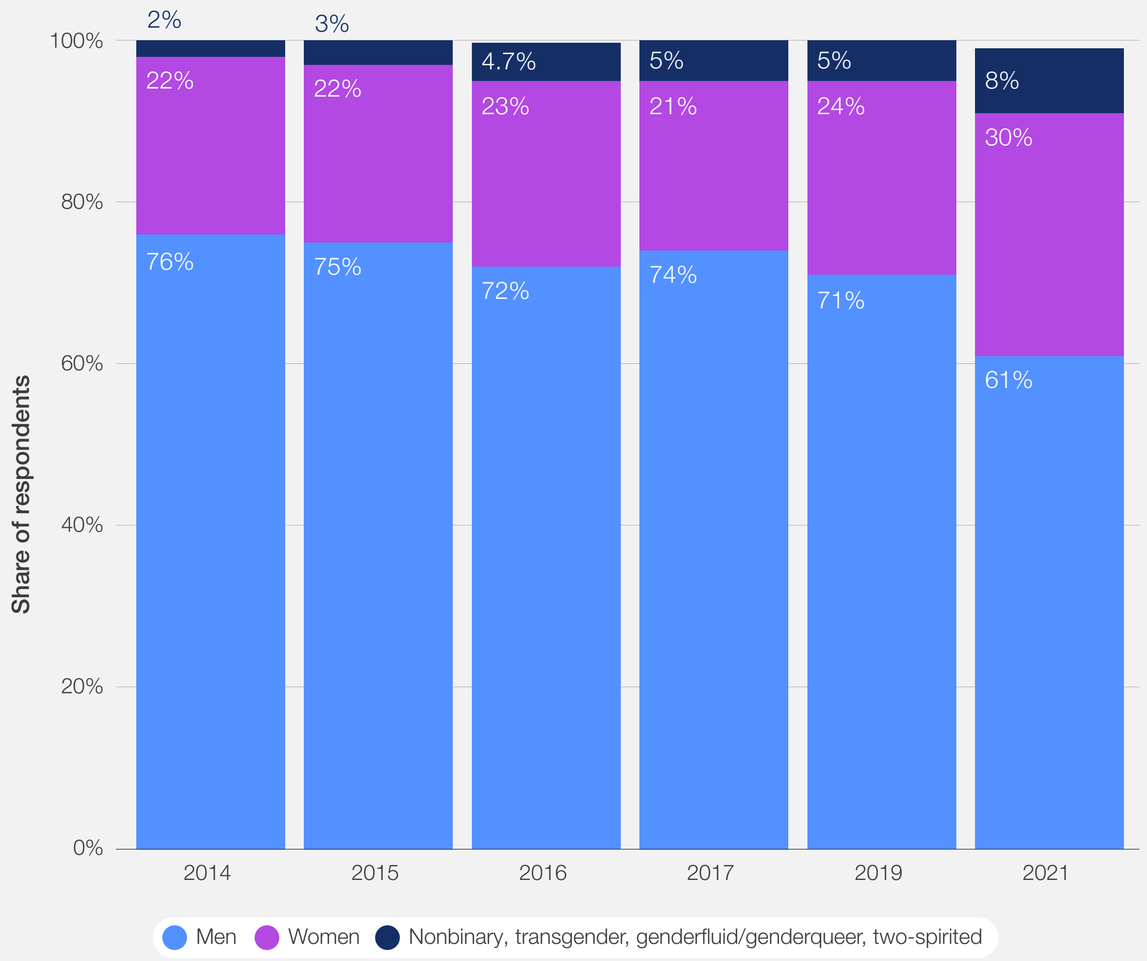
Diverse participants, creators, leaders and moderation

Metaverse leaders, creators and participants have a chance to shape future realities. Enabling a diverse set of voices to participate in this next iteration of digital change and providing them with mentorship and education can increase the visibility and representation of underrepresented groups and promote more equitable and inclusive societies.

Research indicates that “41% of women ha[ve] used a primary metaverse platform or participated in a digital world for more than a year, compared with 34% of men”. Furthermore, female leaders are “20% more likely than their male counterparts to implement multiple metaverse initiatives”; however, “[i]n organizations shaping metaverse standards, 90% of leadership roles are held by men”.[73] These figures highlight a significant gender gap, which is not only limited to metaverse leadership as can be seen in Figure 7.[74]

FIGURE 7

Distribution of game developers worldwide between 2014-2021 by gender



Source: Statista

A lack of representation of gender, people with disabilities, neurodiverse individuals and those belonging to the LGBTQIA+ community or to racially or ethnically marginalized communities results in metaverse experiences that are built for a few over many and may pose wide-ranging challenges for the virtual and physical world. For example, female avatars designed by male creators may influence the reinforcement of gender stereotypes, the objectification of women and uphold unequal power dynamics in societies. Recent research by Dove supports this argument, as it highlights that 60% of girls and 62% of women feel misrepresented in games.[75] It becomes increasingly evident that diverse creators, who bring forth a multiplicity of perspectives and backgrounds, are essential in shaping a truly authentic and inclusive metaverse experience.

To ensure a diverse set of leaders, participants, minds, creators, moderators and builders in the metaverse, companies and government-sponsored digital literacy programmes should create initiatives that enable a broad group of people from different socioeconomic backgrounds to attain metaverse skills and provide mentorships and sponsorships, which can increase access and participation for underrepresented groups. These sponsorships or development programmes should be tailored to the unique needs and challenges of underrepresented racial and ethnic groups.

Equity beyond access: the metaverse as an enabler of global inclusion

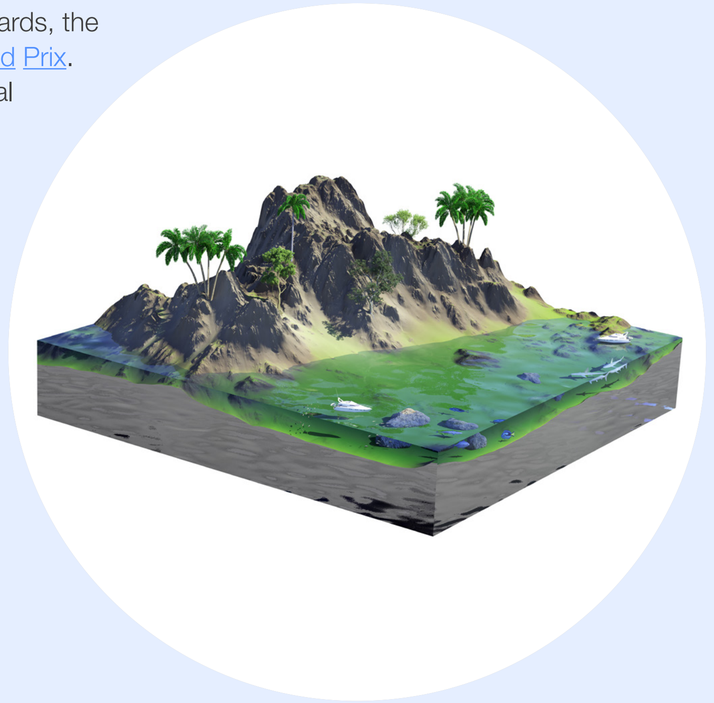
Through its enablement of social interaction and value exchange between the physical and the virtual, the metaverse offers immersive and innovative ways for nations, organizations and institutions to collaborate across borders and industries. It further provides new opportunities for developing nations to participate in global meetings and decision-making processes by increasing their collaboration with developed nations, non-governmental organizations (NGOs) and public and private sector organizations. This could enable developing nations to influence the creation and execution of initiatives, policies and partnerships more closely.

CASE STUDY

The digitized nation of Tuvalu

Threatened by rising sea levels, with most of its land just metres above sea level, the Government of Tuvalu launched the Future Now Project and build the world's first digitized nation in the metaverse.[76] This includes the digitization of government administrative services and the preservation of historical documents, cultural and identity records, and land and natural resources for future generations. Not only does this initiative preserve the nation's culture, knowledge and history, but it also raises global awareness of the growingly pressing impacts of climate change.

As part of Tuvalu's digitization efforts, the nation launched a campaign that was awarded one of the industry's most prestigious awards, the 2023 Cannes Lions Titanium Grand Prix. The judges felt that the "First Digital Nation" campaign could present a long-term solution for developing nations whose very existence is threatened by climate change and rising sea levels.



Additionally, at the World Economic Forum Annual Meeting 2023, Satya Nadella described how AI's integration in the metaverse would significantly impact how people collaborate, learn and solve problems together across space and time.[77] AI's evolving ability to provide live translation across a multitude of languages in interactive social and professional settings will improve accessibility, minimize barriers and bring people and nations closer together to understand each other's views and collaborate effectively.

Representation and avatar customization

A broad range of avatar customization options, the possibility to present one's most authentic self and the liberation of individual identity and expression in the metaverse promote individual and collective well-being and are shown to positively contribute to self-esteem.[78,79] Case studies by Friends with Holograms have shown that representing anonymized avatars in a corporate workshop context can support collaboration and increase engagement, especially of individuals of more junior levels in corporate hierarchy.[80] In the broader context of empathy, VR and the metaverse have shown to be powerful tools for perspective-taking and increased empathy.[81,82]

Next to appearance, inclusive customization options for avatars include voice, sound and non-verbal communication. Since non-inclusive design options could further reinforce stereotypes and biases in society, avatar design options need to represent a diverse set of individuals, be accessible for everybody and should not enforce exploitative economic models (e.g. need to achieve level 4,000 before unlocking skin tone customization or pay £50). While a diverse range of customization options enables a larger number of people to display their most authentic selves in virtual or augmented realities, metaverse builders and participants should be sensitive to the potential impacts of users freely using avatars of a different race or culture to their own. As cultural appropriation, identity tourism or digital blackface in the metaverse can perpetuate harmful stereotypes or misrepresentations, resources, education and awareness to address avatar misuse should be provided and moderation policies put in place.

CASE STUDY

Idoru

The app Idoru is one example of inclusive avatar design tools, as it allows users to create hyper-realistic digital avatars, bridging the realms of digital identity and virtual fashion. It empowers users to exercise bodily and financial autonomy over their virtual personas and supports virtual fashion and beauty options by brands that are aligned with the company's values on diversity and inclusion.

Metaverse accessibility

Considering accessibility for people with disabilities in the design of metaverse software and hardware can ultimately benefit all users, implying that universality and thus accessibility should be implemented into metaverse experiences by design. For instance, haptic feedback, such as vibrations or force feedback, can not only help users with visual or auditory impairments to navigate the virtual world but also enhance the overall immersive experience for all. AI-driven tools such as sign language avatars or real-time captioning could further include deaf people in a broader range of activities while eye-tracking technology could enable individuals to navigate through eye movement. The metaverse and accompanying technologies, such as brain-computer interfaces, can further enable individuals with cognitive or physical impairments to participate in augmented, guided activities. In a professional context, people with disabilities might be able to re-enter the workforce and do work that gives them purpose and meaning. A person in a wheelchair, for example, could go back to their old job of inspecting industrial machinery due to the metaverse and digital twin enablement of remote inspection.

CASE STUDY

Floreo

The company Floreo helps neurodivergent users to navigate everyday life through social, behavioural, communication and life skills training in virtual reality. Vision Buddy has developed a VR headset that aids senior citizens with zoom capability and supports them to be more independent.[83]

However, physical impairments and disabilities related to mobility, vision, hearing, dexterity or speech have a significant influence on the opportunity to participate in metaverse experiences. Some metaverse experiences may require physical movement or dexterity that some people with disabilities may not have. Input devices, navigation and audio and visual cues should always be designed with accessibility in mind. It is important to acknowledge that in the current iteration of the internet, many of these challenges are already considered and eliminated through inclusive design options. Consequently, it is essential to carry on web 2.0's learnings and translate them into a metaverse context while taking them a step further for a truly human-first metaverse.

BOX 6

Limited adoption of diversity and inclusion practices in XR industry

According to an annual survey among XR professionals conducted by XR Inclusion, "only 47% of respondents reported that their respective companies incorporated considerations of diversity and inclusion in the design of XR products and services. This statistic reflects a consistent trend from the previous year, suggesting no significant change in the adoption of diversity and inclusion practices within the industry".[84]

The metaverse as an enabler of a more equitable physical reality

A growing body of research finds that the metaverse possesses the capacity to enhance empathy and reduce bias by enabling individuals to embody others and experience life from different perspectives. Through the option of anonymity, people can freely engage in perspective-taking, challenging preconceived notions and biases. However, the degree of empathy that is evoked through an experience in VR is dependent on multiple factors such as experience quality, presence, embodiment and flow.[85,86]

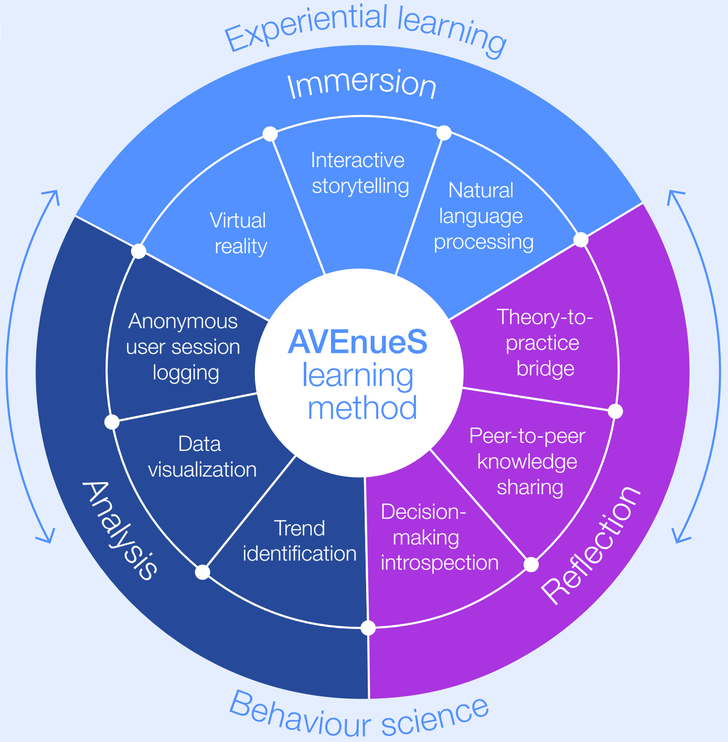
BOX 7

AVEnueS

AVEnueS is a learning method that immerses social workers into highly realistic scenarios designed to evoke a response, helping them to emotionally prepare to enter a household and check-in on a child's well-being, for example. The tool aims to help users come to a deeper understanding of their own thought processes in terms of how they make decisions and develop opinions. It offers an opportunity to broaden each worker's ability to observe, inquire, interpret and reflect in a way that informs a more robust and firmly grounded professional opinion.[87]

FIGURE 8

AVEnueS learning method



Source: Accenture

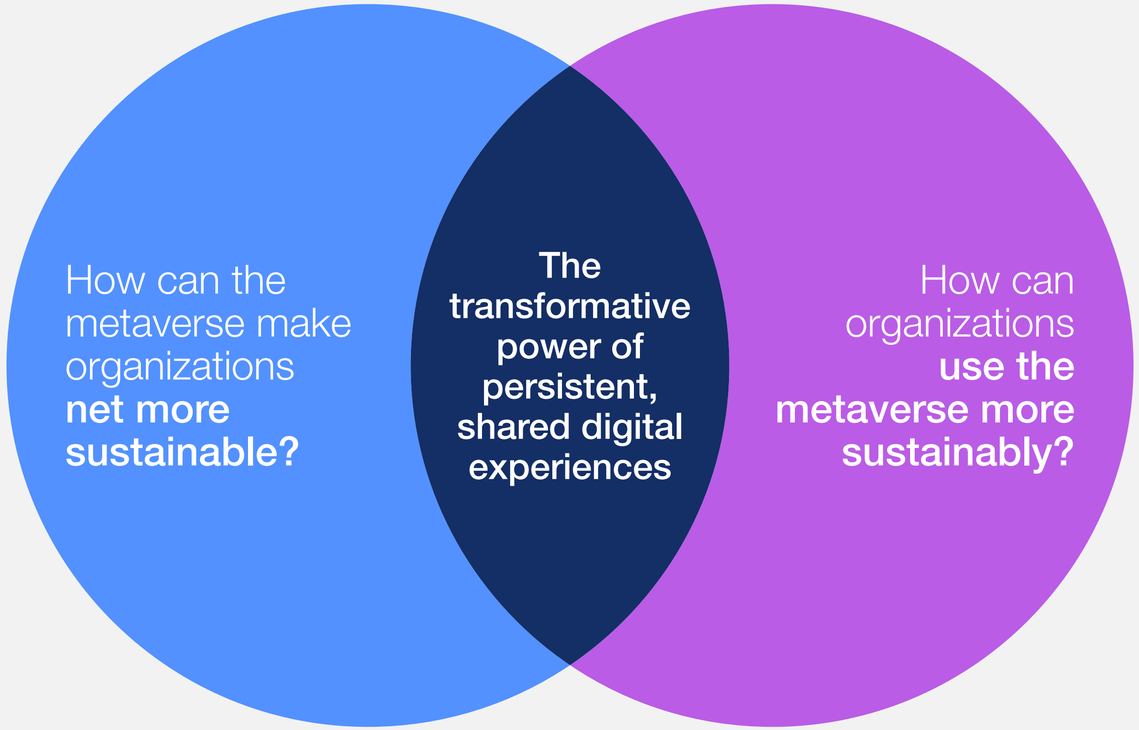
4 Sustainability

According to the Intergovernmental Panel on Climate Change (IPCC), climate change is expected to have “increasingly severe, interconnected and often irreversible impacts… on ecosystems, biodiversity and human systems”.[88] The IPCC further estimates that “in the next decade alone, climate change will drive 32-132 million more people into extreme poverty”.[89] Transport, electric power and (the manufacturing) industry[90] are shown to be some of the world’s biggest polluters.

Technological innovation and thus the metaverse, AI and associated web3 technologies will help to reimagine life as it is known today and enable new facets of sustainable value chains and climate action – acting as a powerful tool to lower climate impact in those three industries while contributing positively to individuals’ behavioural changes. Hyper-realistic worlds and the overlay of virtual information on the physical through XR capabilities allow users to embody and understand nature in entirely new ways, simulate entire factory operations with ease, and track, trace and measure raw materials from the source. While there is a risk that the metaverse could accelerate environmental degradation if concerns are not properly understood and a net-zero approach to development and implementation is not prioritized, there is an array of opportunities to harness the metaverse as a force for good and an enabler of sustainability – helping to accelerate progress towards achieving net-zero emissions.[91]

FIGURE 9

A two-fold approach to the metaverse sustainability



In the frame of this chapter, metaverse and sustainability will be explored from two perspectives.

Select the different perspectives in the Venn diagram to discover more

Environmental challenges of metaverse technology

Metaverse technologies and capabilities denote significant energy impact that accumulates from the energy use required to enable transactions, digital experiences, data storage, processing and more. Leaders must consider the hardware and technology implications when implementing metaverse-related applications to ensure a viable and sustainable continuation of digital transformation.

FIGURE 10

Metaverse environmental impacts – non-exhaustive

Input resource extraction

Increased need for finite resources (i.e. minerals, metals etc.) as input materials to manufacture metaverse-enabling devices, infrastructure etc.

E-waste generation

Potential increase in electronic waste as rapid innovation in XR technology may lead to current devices quickly becoming outdated or obsolete.

Energy consumption

Increase in overall emissions associated with life cycle technology use resulting from the energy intensity required to manufacture and operate metaverse applications.

Hardware considerations

E-waste generation: The world generated 53.6 metric tonnes (Mt) of e-waste in 2019 – an average of 7.3kg per capita – and is expected to grow up to 74.7Mt by 2030[93] with this estimate excluding XR or AR devices.

According to Statista, consumer augmented reality glasses sales are expected to increase from 10,000 units sold in 2019 to 1.59 million units sold by 2024,[94] indicating a potential net increase in global e-waste. VR headset forecasts indicate growth from unit sales of 6.1 million in 2021 to 16.44 million unit sales by 2024. Recent augmented device launches from Apple's Vision Pro, projected in early 2024,[95] and Meta's new Quest 3 suggest that this forecast could rise considerably over the same period.[96]

Simultaneously, increases in 2D desktop experiences will see a rise in laptop and smartphone sales.[97,98] Greater emphasis on product design will be required to drive greater efficiency, minimize console energy use and extend the useful life through power management features such as auto-power down requirements, modal power caps, device repair services and more.

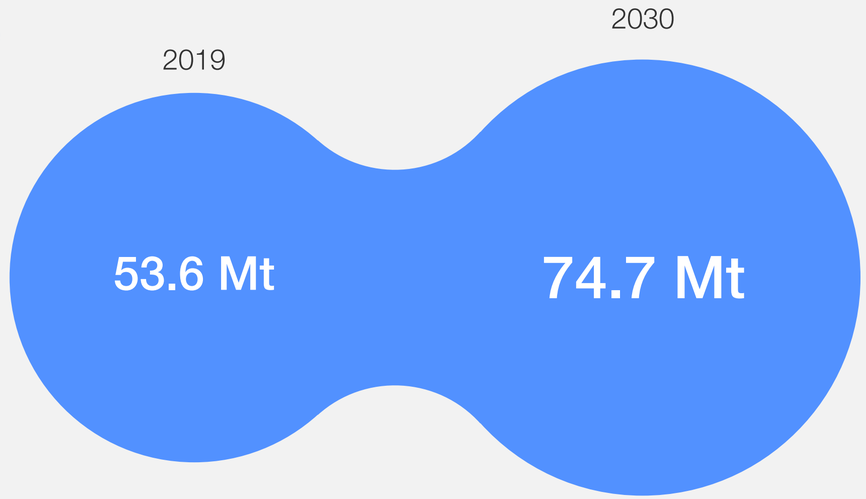
Production: Metaverse hardware production involves various processes that require significant amounts of water, including manufacturing, cooling and cleaning.[99] As the demand for hardware grows, the amount of water used in production could increase, potentially leading to water scarcity in regions where resources are already limited.

Furthermore, metaverse hardware relies heavily on earth minerals such as silicon, gallium arsenide and cobalt, which are used in components such as semiconductors. The commercialization of new compounds for enhanced semiconductor speed and reliability is already catalysing demand for other minerals. As a result, mineral supply chains are strained.[100]

Moreover, the mining of these minerals can cause environmental damage, including soil and water pollution, habitat destruction and health hazards for local communities. Embedding sustainable design practices (including recycled plastic or biodegradable materials), modular designs that allow for easy replacement, responsible sourcing and upgrading of components, as well as hardware reuse, will help to reduce e-waste.

FIGURE 11

E-waste generation



Software considerations

Cloud and edge computing: Edge data centres and devices are set to play a crucial role in the development of the metaverse.[101] To ensure a successful experience, the user must be able to view a rendered virtual environment with utmost clarity, and the system must respond in real time to any gestures or actions by the user.[102] However, analysts at Intel highlight that the global computing infrastructure would need to be 1,000 times more powerful to sustain the metaverse.[103] In 2018, data centres were shown to use more than 2% of the world's electricity and emit roughly as much CO_2 as the airline industry,[104] indicating a pressing need to transition to greener IT for the metaverse.

By moving processing tasks from centralized servers to edge devices, edge computing could reduce the energy consumption of the metaverse by reducing the total amount of data traversing the network.[105] Edge devices can help handle the increased demand without overloading centralized servers while also enhancing the user experience by providing a higher quality experience through low-latency networking and powerful computing.

> **Edge computing technology is one such innovation that will support the development of a sustainable metaverse at mass scale … It is critical to that vision, so its growth is inevitable.**
>
> Prasad Joshi, Senior Vice-President and Head, Emerging Technology Solutions, Infosys

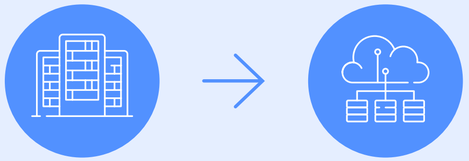
BOX 8

Sustainable cloud journey: Shifting from on-premise data centres to the public cloud

Significant energy consumption and, consequently, CO_2 emissions are linked to the metaverse's need for computing power and data storage and thus cloud computing and data centres. Many cloud service providers have committed to near-term net-zero supply chains, and data centre companies have followed this trend. Research found that shifting from on-premise data centres to the public cloud can reduce an enterprise's energy use by 65% and cut carbon emissions by more than 84%.

Furthermore, migrating existing private workloads to a public cloud could reduce global CO_2 emissions by nearly 60 million tonnes annually – equivalent to taking 22 million gasoline-powered cars off the road.[106] While the first step towards a sustainable cloud journey begins with selecting a carbon-thoughtful provider, software should be built with sustainable software engineering practices, application optimization, sustainable products/services and circular operations in mind.

Outcomes typically observed when transitioning from on-premise data centres to the public cloud include:

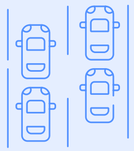


↓ 65%

reduction in energy use

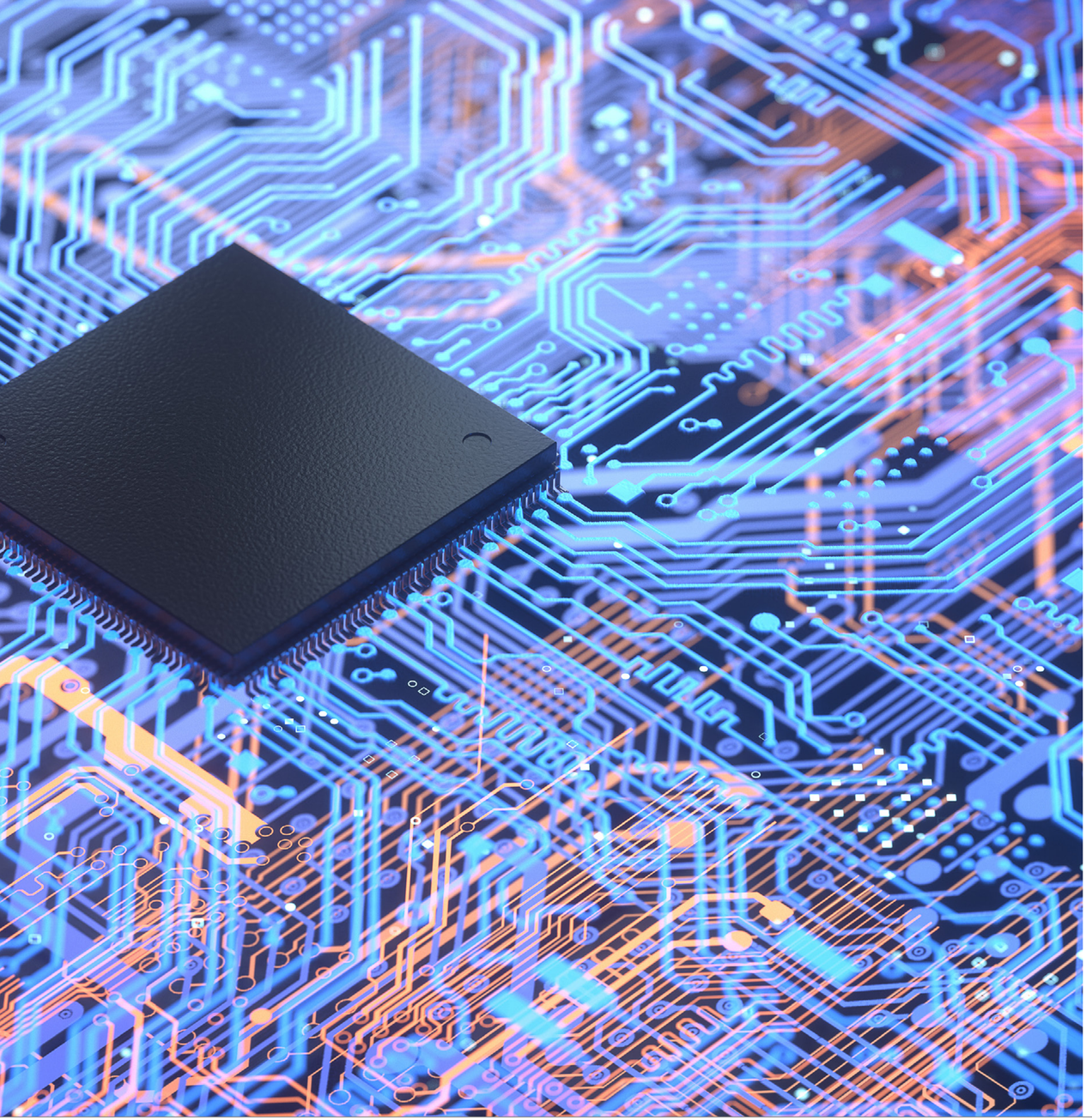
↓ 84%

cut in carbon emissions



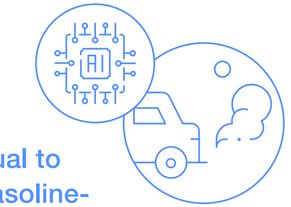
22 million

Migrating to the public cloud could reduce global CO_2 emissions by nearly 60 million tonnes annually, equivalent to taking 22 million gasoline-powered cars off the road



Artificial intelligence (AI): The environmental impact of AI in the metaverse is a significant concern, as training a single AI model can emit carbon equivalent to five cars throughout their lifetimes,[107] while the deployment of AI models and the demand for data will further amplify energy consumption.[108] Creating a generative AI model with 110 million parameters uses as much energy as a round-trip transcontinental flight, while the larger chat generative pre-trained transformer (GPT)-3 model with 175 billion parameters consumes electricity and generates carbon dioxide equivalent equal to emissions from 123 gasoline-powered cars driven for a year.[109] The World Economic Forum's AI Governance Alliance has recently launched to champion responsible global design and release of transparent and inclusive AI systems.

The GPT-3 model with 175 billion parameters consumes electricity and generates carbon dioxide equivalent equal to emissions from 123 gasoline-powered cars driven for a year.



Blockchain: Blockchain technology's reliance on energy-intensive consensus mechanisms and the associated carbon footprint make it detrimental to the environment. However, recent examples such as Ethereum's shift from proof of work to proof of stake has shown the significant effects the choice of code can have on energy consumption of decentralized applications. A comprehensive analysis can be found in the World Economic Forum's recent reports on *Guidelines for Improving Blockchain's Environmental, Social and Economic Impact* and *Blockchain for Scaling Climate Action*.

Extended reality (XR) or spatial computing: While immersive user experiences have the potential to promote a sustainability mindset and foster climate activism (see section 4.3), it is crucial to consider that from a software development, runtime and maintenance standpoint, spatial computing like VR, AR and MR, are likely to generate a considerable amount of carbon emissions. This highlights the need for a comprehensive analysis on the carbon impact across the value chain in future studies.

Consistent with the commitment to guide responsible and sustainable technological advancement, it is crucial to explore strategies for mitigating any adverse effects the metaverse may have on the environment.

Metaverse impact across the value chain

The metaverse describes a fundamental and ongoing digital transformation, affecting businesses' entire value chains. Leaders will need to reimagine how they use metaverse technologies, while ensuring net positive environmental outcomes. The subsequent graphic aims to outline a non-exhaustive view of the sustainability opportunities the metaverse presents throughout the value chain.

In the context of the industrial and enterprise metaverses, future work will delve into a comprehensive analysis of the metaverse's impact across the entire value chain, providing a deeper understanding of its implications and opportunities to improve existing business processes.

FIGURE 12

Metaverse sustainability through business processes (value chain) – non-exhaustive overview

Research and development

The metaverse can facilitate immersive cross-border and cross-sector collaboration through its capabilities of XR and multilateral value exchange. Digital twins enable real-time virtual simulations – multiple scenario modelling and visibility of a product's life cycle and climate impact.

Click on the icons to explore elements of the value chain

Sustainability through immersive user experiences

Behavioural impact through immersive sustainability experiences

The metaverse can drive individual climate activism and behavioural impact towards a sustainability mindset and climate activism through the simulation of climate impact. It can provide first-hand experiences and opportunities to feel closer to and embody nature that would otherwise be too remote or dangerous to explore. The effectiveness of VR simulations on behavioural change in isolated environments has proven to be significant. However, do these outcomes hold in a connected metaverse environment that may include echo chambers, disinformation and misinformation as well as increased sensory inputs?

1 Virtual fieldtrips and climate education

Immersive metaverse experiences are powerful tools to unlock awareness and in-depth understanding of environmental issues, driving behavioural change and climate action. Furthermore, immersive environments are shown to be more persuasive than comparable information in a printed or video format, leading to more significant pro-environmental change.[110] Virtual field trips to teach students about ocean acidification have proven effective,[111] and virtual illustrations of the amount of energy used during a shower resulted in a decrease in hot water use in the natural world.[112]

Experiences such as Green Game Jam, Untamed Planet and the World Integration Loop drive positive environmental impact that encourages real-world sustainable action inspired by virtual exposure to otherwise inaccessible habitats. Gamified programs on biodiversity, such as Microsoft Hong Kong Discover2se have been implemented by primary schools with an aim to develop environmental literacy and sustainability mindsets from a young age.

2 Virtual events and collaboration to reduce travel

By creating a virtual world that is accessible to anyone with an internet connection, the metaverse has the potential to revolutionize the way people work, learn and socialize, while simultaneously reducing their impact on the environment. Remote work in the metaverse could lower commutes and carbon emissions, and benefit the urban use of space.

$114 billion

Global virtual events market size was valued at $114 billion in 2021 and is anticipated to expand at a compound annual growth rate (CAGR) of 21.4% from 2022 to 2030.[113]

CASE STUDY

Touchcast

Touchcast, a leading virtual experience player that uses MR and AI to host immersive virtual events and the ability to create virtual twins of organizations own spaces has launched an emissions calculator that allows users to understand how a move to a hybrid or virtual event can have a positive impact on the environment, providing people with the insight to take action, while also delivering rich immersive experiences that are more accessible and engaging for the audience.

CASE STUDY

World Economic Forum's Global Collaboration Village

Ocean hub in the Nature and Climate Centre: Kelp conference room and mangroves immersive experience

At the Annual Meeting in Davos 2023, the World Economic Forum hosted its first-ever metaverse-enabled multilateral meeting in its ocean hub, allowing participants to discuss seafood loss and waste while immersed in a virtual ocean world. The meeting included remote participation from outside of Davos, enabled through the connective power of VR. The Forum is planning for additional meetings in the course of 2023 and beyond, which would promote inclusivity for global stakeholders to join critical discussions as well as carbon footprint savings from travel reduction.

The Forum also premiered the mangrove immersive experience where users were transported into a multi-faceted ocean world, where they could plant mangrove saplings underwater on the ocean bed and see the effect on an accelerated timescale, with saplings sprouting instantaneously, clearing the water of sediment and welcoming fish back in the coastal environment, illuminating and reinforcing the need to protect coastal ecosystems.

↑ Kelp conference room
← Mangrove immersive interaction

Source: World Economic Forum Global Collaboration Village

3 Embodiment of nature

The value of sensory experience may be significantly higher if experienced while embodying nature itself. Research indicates that embodying non-human beings, such as plants or animals in VR provokes reflective processes on one's own role in nature.[114,115] Embodying nature and first-hand experience of climate change significantly increases environmentally sustainable behaviour in real life, and more than doubles the likelihood to engage in voluntary education around climate change and its impacts.

These findings do not only hold short term but were shown to impact behaviour even one month after the virtual experience.[116] Virtual embodiment is shown to increase understanding of others, decrease biases and change real-life attitudes and behaviours.[117]

4 Environmentally conscious consumption

Immersive technologies such as VR and AR can reduce waste by allowing customers to virtually interact with products, such as trying for fit virtual test drives before purchasing, thereby helping to reduce waste by lowering return rates and carbon emissions.

Spotlight on the retail challenge:
Each year in the US alone, $400 billion worth of merchandise is returned, equating to:[118]

5 billion

pounds of retail waste sent to landfills in one year

15 million

tonnes of CO_2 emitted yearly throughout the retail returns process

8 billion

By 2025, waste from returns in the US could reach 7.8 billion pounds, and carbon emissions could reach 23 million tonnes, with returned items projected to reach 8 billion.

BOX 9

Metaverse as an enabler of more sustainable retail

The Google Pixel 6 "Material You Fashion Collection" launched a carbon neutral 12-piece collection with digital fashion houses The Fabricant and DressX. Users were able to upload their photograph and then virtually see themselves dressed in their chosen item.[119]

More leaders are beginning to use metaverse technologies to help combat environmental challenges, with 64% of leading consumer brands starting to invest in immersive experiences.[120]

Snapshot

Role of digital twins in accelerating sustainability

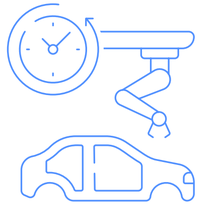
Adoption of digital twins can help to counteract environmental impact, driving both sustainability efforts and supporting the transition to a more circular economy. These technologies allow users to design, test and model disruptive new sustainable products and processes at speed and scale, all virtually, significantly decreasing time to market and minimizing the risk associated with complex innovations and projects.

Today, the use of digital twin technologies can be seen in the development of 85% of the world's electric vehicles (EVs) or powering breakthrough prototypes, such as the world's first solar aircraft and new biomaterials.

Research by Accenture and Dassault Systems found that across five industry use cases spanning construction, consumer packaged goods, electronics, transport and logistics, and pharmaceuticals, digital twin technologies could unlock up to 7.5 gigatonnes of CO_2 equivalent ($GTCO_2e$) emissions reductions by 2030.[121]

BOX 10

Metaverse technology in car prototyping



↓30%

Digital twins technology enabled SEAT to reduce the number of prototypes needed to be physically made prior to launching a new model by half while lowering production time by 30%.[122]

CASE STUDY

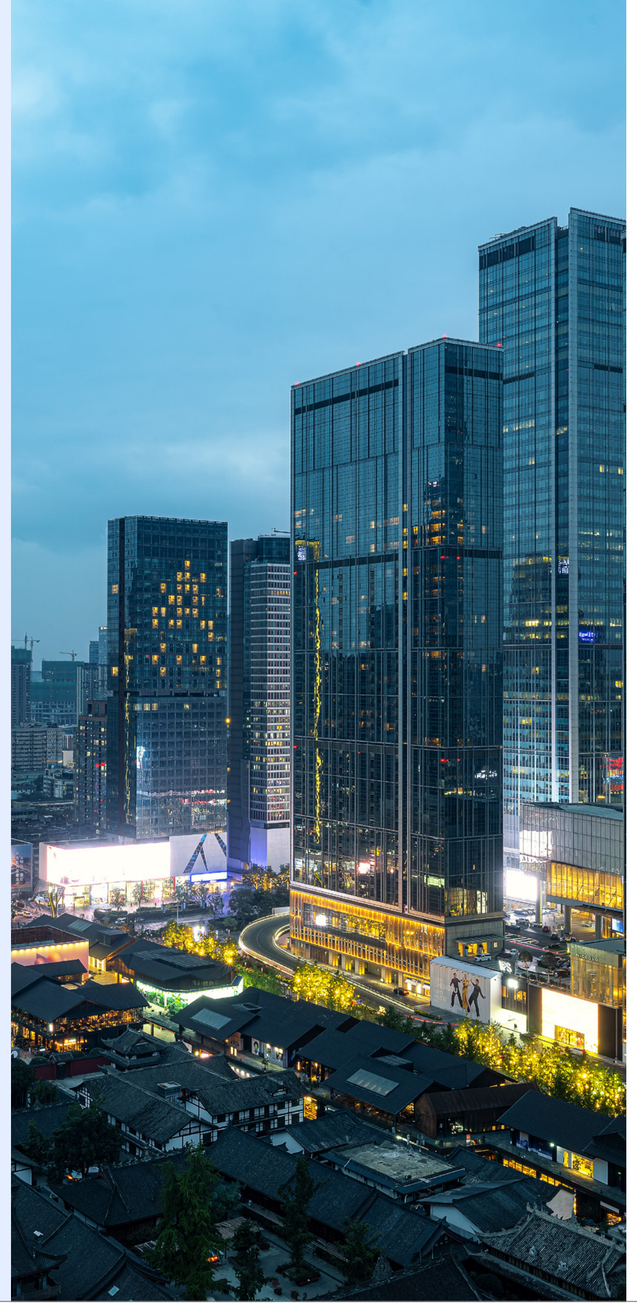
Nvidia Omniverse and BMW Group – World's first virtual factory

In the age of the metaverse and AI, new manufacturing factory projects are going digital-first. Nvidia Omniverse and AI has helped BMW set up new factories faster and deliver greater operational efficiency and savings, as well as sustainable innovation by simplifying the entire factory planning process. Factory projects and planning, once a complex process that required connecting tools, datasets and specialists from around the world, can now happen in a virtual factory – optimizing layouts, robotics and logistics systems years before a new factory opens. As a result, BMW launched the world's first virtual factory – with the physical EV plant set to open in Debrecen, Hungary, in 2025.[123]

CASE STUDY

Aden – Digital twin for commercial centre in Chengdu, China

Aden, a leading integrated facility management service provider has created a digital twin for one of the commercial centres in Chengdu, China. It monitors, aggregates and understands data to plan and execute inspection, maintenance and repair activities. Expected benefits from this project include reduced annual energy consumption by 20%, lower water use and waste generated and improved health and safety performance. 3D simulations to model and simulate the behaviour of the building systems are used to predict and optimize energy consumption under different operating conditions.[124]



Currently, more than half of the global population live in cities, consuming 78% of the world's primary energy.[125] Digital twin technologies can help in the overall urban transition to net-zero carbon cities by enhancing urban design through simulation, planification and optimization. This enables city planners to test various responses to everything from population growth and resource management to public events and building patterns and implement those that create the safest, most positive experiences.

The application of digital twins, in conjunction with AI and broader metaverse technologies will play a central role in the digitization of industries, helping to unlock sustainable innovation through adaptive, collaborative and autonomous automation and product creation – all to be explored further in future work.

BOX 11

Metaverse enabled smart buildings

↓30-80%

Energy consumption in buildings can be reduced by 30-80% using proven and commercially available digital twin technologies, often within the broader framework of smart cities.[126]

5 Economic impact and empowerment

The metaverse will bring economic opportunity; the models that realize this from a consumer-facing perspective were explored in the *Demystifying the Consumer Metaverse* report.

Economic empowerment is the capacity of people to participate in, contribute to and benefit from the growth of a market in ways that recognize the value of their contributions. The metaverse will further empower creators, brands and users alike, by unleashing a new canvas, toolsets and currencies that unlock new ways to express, collaborate and monetize their work, be that for monetary or intrinsic reward.

There are, however, challenges that must be addressed to ensure a sustainable and economically viable economy in the metaverse, such as the treatment of IP rights, portability of ownership and identity and the mechanics that must be in place to support transparent and fair value distribution, so that individuals are compensated for their work and experiences fairly.

The growing creator economy

Evidence of underlying growth is apparent across the metaverse economy. Participation and economic activity are already material, with the pace of growth continuing to accelerate.

To note is how value distribution in the creator economy and the metaverse will be contingent on factors such as ownership and the role of platforms, from fees taken by platforms, to whether platforms will be owned by the collective and fees distributed accordingly.

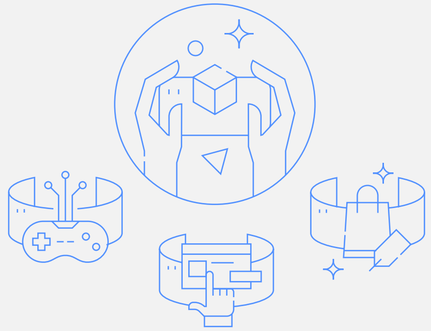
FIGURE 13

Economic and consumer behaviours in the metaverse

Economic activity in the metaverse

$200 billion

estimated level of metaverse commerce in 2022 concentrated in gaming, enterprise and retail



$10.4 billion

investment in companies related to the metaverse

300 million

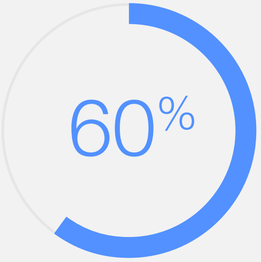
digital asset users in the metaverse by start of 2022

Consumer behaviours in the metaverse

New ways to express yourself:

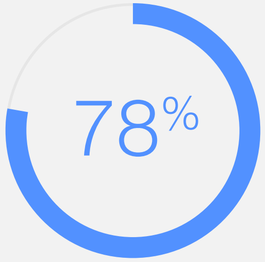
of consumers look forward to creating and monetizing content in the metaverse

New ways to make a living:



of consumers see the metaverse as a business opportunity

New ways to collaborate:



of brands and creators want platforms to be more involved in their projects

The rise of creators and the broader creator economy is the digital manifestation of the rise of creativity as a key element in economies, societies and everyday lives. The scale and scope of creators and the creator economy is large and growing. Creators number more than 300 million people across nine large nations, including more than 85 million Americans, according to a 2022 survey.[127]

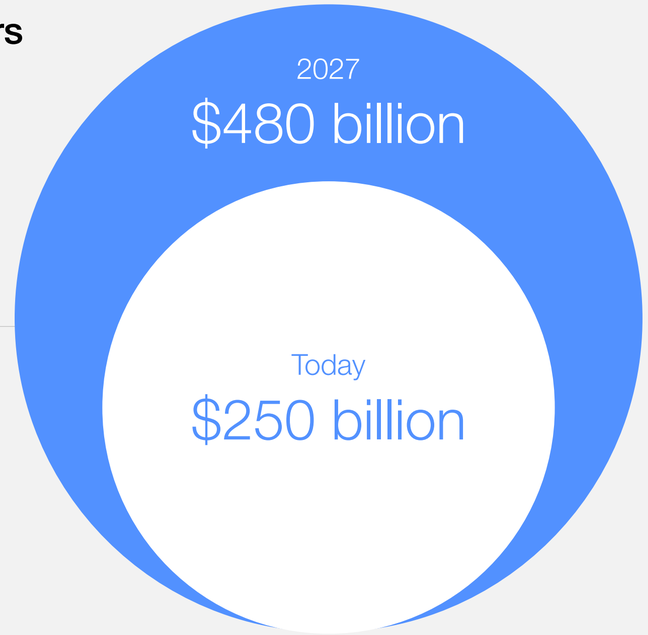
> **The creator economy has boomed globally in recent years, thanks to more advanced social media applications, popular creative tools, people's desire to express themselves and other factors.**
>
> Tony Ng, Managing Director of Greater China, Adobe

FIGURE 14

Creator economy by numbers

Creator economy market size

192%
increase by 2027



1 billion
self-identified creators over the next 5 years

$1.3 billion
venture capital funding for the creator economy in 2021

165 million
people grew the global creator economy to $100 billion over the past 2.5 years

Sources: "The Creator Economy Explained: How Companies Are Transforming The Self-Monetisation Boom", CBI Insights, 15 June 2021; "The Creator Economy Could Approach Half-a-Trillion Dollars by 2027", Goldman Sachs, 19 April 2023; Adobe, Adobe Future of Creativity: 165M+ Creators Joined the Creator Economy Since 2020 [Press release], 25 August 2020.

The creator economy has been through multiple phases of evolution and the metaverse and web3 are redefining the art of the possible for creators once more. Today's leading digital platforms are providing opportunities for users with new avenues to monetize their work, from virtual goods or events, to leasing of assets and more.

For example, The Sandbox has introduced a self-service mechanism that enables creators to design, build and sell everything themselves, with limited administrative support by the platform, resulting in a revenue share of 95% in favour of creators (e.g. for the creation of items, wearables, tickets and more), with The Sandbox only taking a 5% platform fee.

The metaverse provides creators with another experience and economy layer,[128] in which to interact with their community and create content, engage and transact. These experiences give unprecedented levels of control to the user, forging loyalty – and helping them to discover joy and delight in new forms of self-expression. Further insight on goods and experiences, payments and commerce economic models for brands and creators can be found in the *Demystifying the Consumer Metaverse* report.

Generative AI is powering creators in the metaverse

Platform spotlight

Empowering creators through the integration of generative AI, new low/no code tools and features, and fairer pay-outs.

CASE STUDY

Generative AI on Roblox – the future of creation

Roblox Studio provides creators with a platform that enables end-to-end tools, services and support to build immersive 3D experiences – with the ability to publish immediately on all popular platforms, reaching 58.8 million people daily worldwide. Roblox is now embedding generative AI onto the platform, enabling every user to be a creator, not just those comfortable with Roblox Studio and other 3D content creation tools. These AI tools not only accelerate creator productivity but can also significantly lower the technical skills needed to bring ideas to life.

Some creators may know how to code but have limited experience creating high-fidelity 3D models. Others may be more experienced in model design, but less experienced in coding. In both cases, a beginner will be able to bring their imagination to life in a Roblox experience by introducing a set of tools more accessible to a typical user than exists in any environment today – such as voice and text or touch-based gestures.

Generative AI tooling will help make creation intuitive and natural for users, creating a generative model for all types of content at once – image, code, 3D models, audio, avatar creation and more – and be directly embedded into experiences, allowing Roblox's daily users to create unique content that can be shared across the platform.[129]

CASE STUDY

Unreal Editor for Fortnite (UEFN) and Creator Economy 2.0 on Epic Games

UEFN is a version of Unreal Editor that can create and publish experiences directly to Fortnite. With many of Unreal Engine 5's powerful features now easily accessible, creators and developers have new creative options for producing games and experiences that can be enjoyed by more than 500 million Fortnite player accounts. UEFN is being launched alongside Creator Economy 2.0 – a new way for eligible Fortnite island creators, including Epic, to receive money based on engagement with their published content.

Engagement pay-outs proportionally distribute 40% of the net revenue from Fortnite's item shop and most real-money Fortnite purchases to the creators of eligible islands and experiences, both islands from independent creators and Epic's own, such as Battle Royale.

Epic will also launch a unified 3D marketplace later this year, where creators can find, publish and share digital assets for use in creating digital experiences and earn an 88% revenue share.[130]

> **AI could help artists create new metaverse spaces that exist in our dreams.**
>
> Refik Anadol, Director, Refik Anadol Stuidos; Village Partner, Global Collaboration Village, World Economic Forum[131]

The metaverse also has the potential to vastly expand the reach of creators and brands, giving rise to a builder economy, relating not just to the individual but teams of individuals, connecting and building companies, creating experiences or digital goods, such as items for avatars to wear on platforms like Roblox for monetary gain.

Note: AI can help with the compositional aspects of generative world creation. However, although rapidly accelerating, the technology today for generating a 3D model that is readily usable in a virtual world is still in its infancy.[132]

The changing nature of work

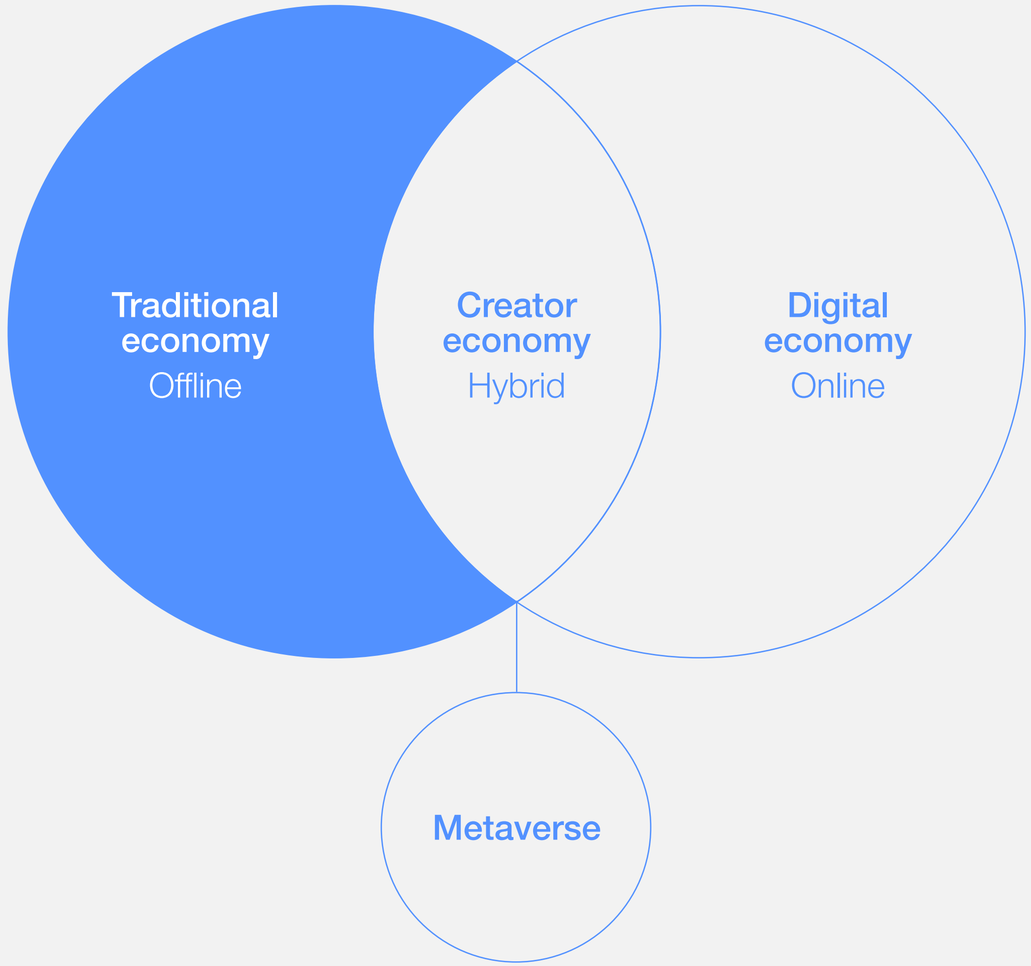
The COVID-19 pandemic introduced trends such as the “great resignation” and a rise in entrepreneurship and content creation to earn a living. These trends have given way to a new ability to engage a community in entirely new ways.

Remote working has already altered the landscape of work within the enterprise, as many companies embrace the concept of “work from anywhere” and are able to find talent in different geographies, sometimes from whole new talent pools. The globalization of talent goes two ways – it means employers can find new talent across the world, and individuals will find opportunities they didn’t have access to before. This is supported by the fact that the metaverse not only allows people to interact in virtual spaces without being constrained by physical boundaries, but allows a sense of presence, which improves collaboration and productivity. Access allows individuals who might otherwise be excluded from traditional economic opportunities to participate in the global economy and potentially earn a living wage.

Select the different areas of the Venn diagram to discover more

FIGURE 15

Shifting definitions of work in the creator economy



Traditional economy

Economic activity that largely entails in-person, physical or offline services, work, activities, and experiences.

Example

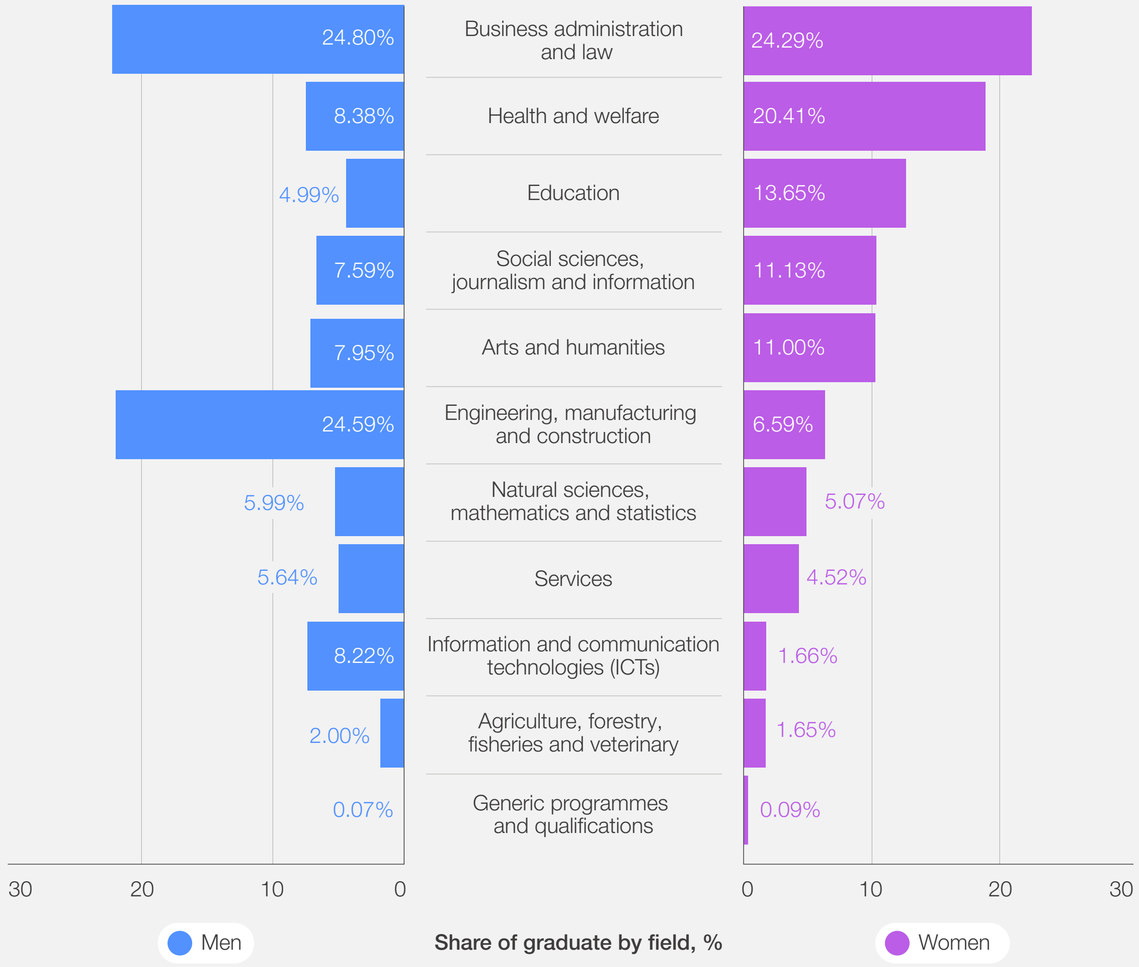
Traditional craftsmen or artists finding new online audiences through streaming their creation process and selling digital prints.

Socioeconomic impact for women in the metaverse and web3

Noted for further exploration, the proliferation of more tech-based job opportunities may result in greater gender imbalance. As noted in the World Economic Forum's *Global Gender Gap Report*, accounting for graduates from all fields, the percentage of female graduates in information and communication technologies (ICT) is 1.7%, compared to 8.2% of males.[133] The ITU reports that more than 50% of the world's women are offline. Women are likely merely to borrow or share mobile phones (often within a household or from a male family member) and are rarely the primary owners of a mobile device.[134] GSMA reports that women are more likely to have simpler feature phones that do not support mobile internet use and are 15% less likely than men to own a smartphone, let alone AR/VR-enabled hardware.[135]

FIGURE 16

Share of graduates, by field and gender, OECD average



Source: World Economic Forum, *Global Gender Gap Report*, 2022.

These disparities in use limit females' access to the full range of opportunities offered by the digital economy. The internet is often perceived as a risk to the traditional social order or seen as unsafe for women and girls. Men (or family/community) gatekeepers may control or restrict access to devices and the internet for women and girls. For example, some rural communities in northern India have banned womens' mobile phone use, and other communities have decrees declaring internet use "immoral" for women. More attention will need to be given to the gender opportunity gap, as these challenges could exacerbate with the emergence of the metaverse.

The macro-economic effects of the metaverse

Many critical questions have begun to arise about the macroeconomic impact of the metaverse. The metaverse economy is already a growing part of the broader global digital economy. In the same way the internet underpins economies today, the metaverse is said to soon be the same and on a broader scale than is known today. The creator economy will help increase the supply of goods and services in the metaverse, and as adoption continues, new financial assets and services (development of payment capabilities), identity infrastructure and other resources will be required to meet demand and deliver on the promise of an open and interoperable metaverse.

The metaverse will impact every aspect of economics, from the future of money, work, education, identity, commerce, media, advertising and more, through the consumer, enterprise and industrial metaverse. Development within the enterprise and industrial metaverse will make its way to the consumer metaverse, and while brands, platforms and creators continue to make strides, major industries from advanced manufacturing to the enterprise have already taken several steps to adopt the metaverse.

Financial transactions in and out of the metaverse

Empowered by new forms of payments and currency, the metaverse is powering a digitally native economy, necessitating robust payment infrastructures, encompassing digital assets as a store of value or cryptocurrencies as means for payment. While cryptocurrencies in the metaverse have captured media attention, metaverse transactions are expected to be conducted in fiat currency, in-platform tokens as well as cryptocurrencies. The interplay of various payment means and currencies is expected to establish a need for services such as on- and off-ramps for currency conversion, wallets to verify ownership, store digital assets and provide access, and custody to protect assets from potential threats. Broad metaverse adoption hinges on the ability to bring identity, money and objects seamlessly and securely across environments.

Aggregate demand[139] impact on monetary policy may also occur as money is created in the metaverse with new currencies or stablecoins, which are then used to purchase physical goods in the physical world, such as a house or car.

Future work will be required to understand the macroeconomic impact of the metaverse in greater depth. This includes taxation from income gained in the metaverse, which is currently ambiguous in terms of tax law, to jurisdictional economics and how metaverse governance may be determined by its equivalent of the uniform resource locator (URL) location and the potential strain this may have on today's lawmakers, law enforcement and court capacity.

FIGURE 17

The metaverse presents a promising new arena of economic opportunity

$3 trillion

The metaverse presents a promising new arena of economic opportunity, potentially contributing more than $3 trillion to global GDP by 2031,[136] resulting in a total contribution of 2.8% to GDP in the 10th year after the start of its adoption curve in 2021.[137]

700 million

projected worldwide users of the metaverse by 2023.

$4.4 trillion

total addressable market for metaverse by 2023, with the highest penetration rate forecasted in South Korea.[138]

Conclusion

The metaverse has the potential to bring about significant social, economic and environmental changes. However, these opportunities come with the responsibility to ensure that access and adoption, health, sustainability, economic impact and empowerment, and DEI are prioritized in the design and deployment of trusted metaverse technology and experiences.

Governments, NGOs and private sector businesses need to collaborate to establish the necessary foundational infrastructure and promote metaverse growth, while ensuring that the digital divide is not widened. Research, use cases and collaboration are essential in exploring the potential impact of technologies that come together to make up the metaverse on various aspects of life. These efforts should focus on areas such as access and accessibility, inclusive and responsible design, fair flow of money and environmental sustainability to maximize the potential benefits of metaverse technology and experiences, while minimizing the risks.

This report gives a comprehensive but non-exhaustive overview of possible social opportunities and challenges in the metaverse and aims to guide future development of metaverse hardware, software and experiences. While this report marks an important first step on the journey towards a metaverse that delivers social value, further longitudinal research that balances positive and negative outcomes, research and analysis of the effectiveness of challenge mitigation strategies, as well as analysis of the impact on businesses' value chain sustainability and entire economies is needed. Furthermore, the establishment of metaverse specific standards and regulation, as well as investment and education are essential to drive an equitable and fair metaverse.

As the metaverse continues to evolve, it presents an unparalleled opportunity to construct more equitable and trusted virtual worlds that can significantly impact physical reality. The insights provided in this report serve as a foundation for companies and individuals to embark on their educational metaverse journeys and translate knowledge into economically and socially viable actions that promote positive change in this next era of digital transformation.

Glossary

Centralized: An organizational or architectural setup – such as environments, platforms or ecosystems – wherein decision-making authority and operational control are consolidated within a central hub. This promotes cohesive management, centralized data storage and synchronized processes.

Cryptocurrencies: Digital currencies that use cryptography for security and are not backed by a central authority, making them decentralized.

Crypto exchanges: Online platforms, or exchanges, that allow users to buy, sell and trade cryptocurrencies in a peer-to-peer setting.

Decentralized: Decentralized refers to an organizational or architectural framework – such as environments, platforms or ecosystems – where decision-making authority and operational control are distributed across multiple nodes or entities rather than concentrated in a central hub.

Decentralized autonomous organizations (DAO): An organization that operates with predefined rules encoded into its protocols and are generally managed by making use of smart contracts and distributed ledger technology (DLT), typically blockchain, to provide transparency, immutability, autonomy and security. All decisions are taken based on programmatic algorithms, where participants can execute their voting rights if applicable.

Decentralized identity: Decentralized identity refers to a paradigm shift in identity management, enabling individuals to assert and control their digital identities without relying on centralized intermediaries.

Digital identity: Refers to the representation of an individual, organization or entity in the digital realm. It encompasses the collection of personal attributes, credentials and information that uniquely identify and distinguish an entity in the online world. Digital identities enable authentication, authorization and access control in various digital interactions and transactions, shaping the way individuals engage with digital services and platforms.

Digital ownership: Trusted and secure management of people's identity, money and objects as they traverse spatial experiences.

Crypto wallet: A piece of software or hardware with which users perform the send/receive operations of digital assets through a blockchain network.

Diminished reality: A set of methodologies for selectively concealing, eliminating and/or seeing through objects in a perceived environment in real time.

Distributed ledger technology (DLT): Refers to a broader concept of a digital record-keeping system that is distributed across multiple participants or nodes. It encompasses various forms of decentralized databases or ledgers that are shared among multiple parties, allowing them to maintain a synchronized and consistent record of transactions or data.

Education equality: The principle that all individuals should have equal access to educational opportunities regardless of their race, gender, socioeconomic status or any other personal characteristic.

Education mobility: The ability of individuals to advance their education and career opportunities through various means such as acquiring new skills, degrees or certifications.

Generative AI: Refers to a branch of artificial intelligence that focuses on the creation and generation of content – such as images, text or music – through machine learning algorithms. Unlike traditional AI systems that primarily perform classification or prediction tasks, generative AI models are designed to generate output by learning patterns and structures from vast amounts of training data.

Human-first metaverse: A metaverse that prioritizes the human needs of the individual and consequently integrates supportive design choices, tools and interactions to respect the persons behind the data. This transcends decisions – from architecture and security to privacy, identity and safety choices.

Interoperability: The ability to interact, exchange and make use of data and resulting information to enable movement, transactions and participant across systems, platforms, environments and technologies.

Loot-boxes: A form of microtransaction in video games where players can earn or purchase virtual items or random rewards in exchange for real money.

Metaverse: The metaverse represents a continuum of digitally enhanced worlds, realities and business models. It is a dynamic environment that uses spatial computing platforms, generative AI, web3 and blockchain technologies to enable augmentation of the real world.

Microtransactions: Small payments made in exchange for digital goods or services, often used in mobile games, e-commerce or social media platforms.

Non-fungible tokens (NFTs): Digital assets that represent unique, one-of-a-kind items or pieces of content, such as artwork, collectibles or virtual real estate. Unlike cryptocurrencies, which are fungible and interchangeable, NFTs are indivisible, have distinct properties and may provide a digital certificate of authenticity and ownership.

Permissioned: A system where access and control are granted to a select group of individuals or entities. It involves setting specific permissions and restrictions on who can participate or make changes within the infrastructure.

Permissionless: Refers to (blockchain) networks without restrictions neither to read nor validate transactions, which means all participants have the same rights. Permissionless networks are also known as public networks.

Spatial computing: 3D interactive content displayed in the real world through digitally augmented physical spaces and in virtual metaverse spaces, accessed via mobile phones, desktop computers and headsets – augmented reality (AR), mixed reality (MR) and virtual reality (VR), otherwise known as extended reality (XR).

Social economics: Primarily concerned with the interplay between social processes and economic activity within a society. Social economics may attempt to explain how a particular social group or socioeconomic class behaves within a society, including their actions as consumers.[140]

Social impact: Describes any improvement that confronts or addresses inequalities and injustices in a community. Different sectors – including businesses, government agencies and non-profit organizations – can contribute to positive changes on a small and large scale. Since social impact advocates address systemic issues, the work and result of social impact require a series of many actions rather than one event.[141]

Social implications: The potential consequences and effects of technology on society, culture and human behaviour.

Social mobility: The ability of individuals to move up or down in social status or economic class based on their education, skills and opportunities.

Social norms: Social norms are the perceived informal, mostly unwritten, rules that define acceptable and appropriate actions within a given group or community, thus guiding human behaviour. Social norms are therefore situated at the interplay between behaviour, beliefs and expectations.[142]

Social value: The positive impact of technology on society, culture and human well-being.

Social values: The beliefs, attitudes and opinions about what is important, both to individuals and to society. A value, therefore, is a belief (right or wrong) about the way something should be.

Society:
Society (metaverse context): The communities that creators, participants and providers live and engage in. Society includes the public and private sector, and its individual and organizational bodies on a local and global level. Not only does society establish social norms, but it also serves a regulatory obligation that replicates to the metaverse.

Society (social science): A large group of people who live together in an organized way, making decisions about how to do things and sharing the work that needs to be done. All the people in a country, or in several similar countries, can be referred to as a society.[143]

Tokenization: The digitization and representation of a physical or digital asset within a distributed ledger. This process brings a more commercialized vision, where people can value and exchange any element based on its supply and demand.

Web3: Describes an emerging portfolio of decentralized technologies, protocols and standards that help to establish provenance, veracity and value of data.

Web 3.0: Web 3.0 describes the evolution of the internet, it is an evolution focused on distributing systems to create a more secure, transparent and open internet experience that enables direct interactions between users and their peers without intermediaries.

Contributors

This paper is a combined effort based on numerous interviews, discussions, workshops and research. The opinions expressed herein do not necessarily reflect the views of the individuals or organizations involved in the project or listed below. Sincere thanks are extended to those who contributed their insights via interviews and workshops, as well as those not captured below.

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