Augmented Reality and Sustainable Behaviour Change: A socio-technical perspective

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Abstract

Digital technologies are transforming industries. As technology continues to advance, it serves as a catalyst for addressing environmental and social challenges. Sustainable solutions are increasingly reliant on innovative technologies such as IoT, blockchain, 3D printing, virtual reality (VR) and augmented reality (AR) applications. In addition, consumers are becoming more technologically connected, demanding transparency and eco-friendly options. AR technology has the potential to advance sustainability practices across various sectors and can help businesses and consumers comply with sustainability principles by reducing waste and evaluating materials. It can be applied in precision livestock farming, agriculture, transportation, safety education, and healthcare. Climate change poses a significant challenge to humanity, with far-reaching impacts on various aspects of our lives. Efforts are needed to expedite the transition to a low-carbon economy and bolster resilience against climate change impacts. Collaboration among academia, businesses, governmental bodies, and individuals is essential for advancing sustainability and bridging the gap between technological innovation and sustainable solutions. As we stand at the intersection of technological innovation, sustainability imperatives, and evolving consumer behaviour, this paper calls for further research on the effectiveness of technology-driven solutions in promoting sustainability and eco-friendly consumer decisions.

Keywords

Augmented Reality, Sustainability, Climate Change, Socio-technical perspective

1. Introduction

Technology is of vital importance in our world today, as it is at the heart of everything we do; it underpins how we learn, work, shop, and communicate (1). Technology has completely changed how we acquire information, and even deal with pressing global issues such as environmental sustainability. It now plays a crucial role in sustaining civilization (2) such as education, healthcare, transportation, retail, and agriculture, amongst others. Thus, various technologies have gone beyond creating a platform through which consumers can access information, they now play a crucial role in the decision-making process of consumers (3), leading to a dramatic change in consumer behaviour (3,4). Notable technologies, transforming consumer behaviour, include artificial intelligence (AI), machine learning, virtual and augmented reality (VR/AR), blockchain, chatbots, internet of things (IoT), 3D printing, cloud computing, and automated shopping systems amongst others (5,6). These technologies are merging in the digital, physical, and social spheres, allowing for enhanced service, and ultimately, leading to new value propositions (7,8).

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Similarly, technology is revolutionising many industries (9), aiding businesses and consumers in creating a sustainable business environment (6). For example, AR provides an opportunity for businesses and consumers to comply with sustainability principles by reducing waste from excessive packaging (10,11) as customers can virtually try products (12,13). Consumers are also able to evaluate the materials that the products are made of and how easily the packaging and the end-of-life of the product can be recycled, to minimise their carbon footprint on the environment.

2. Augmented Reality and Sustainability

Climate change poses a significant challenge to humanity, causing irreparable sea level changes, increased weather-related disasters, and life-threatening temperatures (14–16). There is an urgent need to reduce carbon emissions to prevent the irreversible impacts of climate change on the ecosystem.

The social-technical perspective considers the reciprocal relationship between society and technology as mutually exclusive; they mutually shape and influence each other (17). In the context of sustainability, the socio-technical perspective considers the interplay between people, processes, and technology (18) driven by data to enhance sustainability (19). To achieve evidence-driven sustainability, organizations must leverage technology such as AR, integrate sustainable processes, involve people, and use data to drive sustainable decision-making, as illustrated in Figure 1.

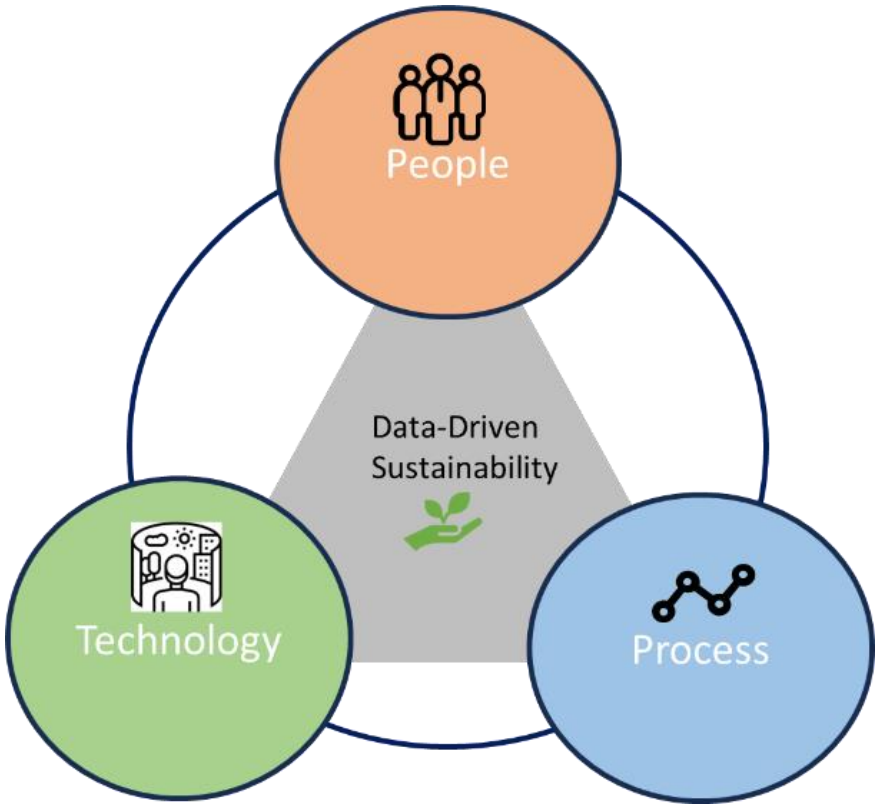

Figure 1: Socio-technical interplay between people, process and technology. Adapted from (18)
Sustainability is the development that ensures current needs are met without compromising the ability of future generations to meet their own needs (20,21). That is, it is the requirements and demands of the current generation to meet their own needs without jeopardising the capacity of the future generation to meet their needs. The 2050 agenda on sustainability sets a strategy to implement the 17 Sustainable Development Goals (SDGs) shown in Figure 2 (22). SDG13 relates

to climate action, which is, having a carbon-free environment by 2050. There is an urgency to achieve these goals of reducing global carbon dioxide emissions by 2030 and achieving net-zero emissions by 2050 (23). According to the United Nations view on Climate Change, global temperatures have risen by 1.3 degrees Celsius since industrialization, and unless a 43% decrease in carbon emissions is achieved before 2030, they are expected to climb by 1.5 degrees Celsius by 2100 (14,15). Human activities are the predominant drivers of climate change (16) and the current trend is not sustainable. Therefore, there is an urgent need to minimise our carbon footprint. Research has shown that digital technologies have the potential to mediate human activities in reducing carbon emissions (24) from a socio-technical perspective. Similarly, augmented reality (AR) has the potential to contribute to sustainable behaviour change (25) from a social-technical perspective.

Figure 2: 17 Sustainable Development goals aimed to transform the world and make it more sustainable(15)

3. Augmented Reality

Augmented reality (AR) is a rapidly growing technology that is gaining relevance in various industries and sectors, including education, entertainment, healthcare, manufacturing, retail, and government. AR technology could also be used to provide information on the eco-friendliness of a product (26), and how to effectively manage the consumption and disposition of the product, ultimately promoting sustainability. AR combines virtual and real environments (27), by superimposing digital content on the real world. AR offers new opportunities for interaction and engagement between the physical and digital worlds (26). The adoption of augmented reality technology in various industries has been ongoing for decades, from NASA to sports broadcasting to automotive repair (28).

4. Use Cases of Augmented Reality

The application of AR across many industries offers relevant and viable solutions to address some of the challenges of sustainability. AR provides designers with a realistic, real-world representation of their designs through digital prototyping (29,30), facilitates collaboration among team members, and enhances user experience by overlaying digital information onto physical objects (31), promoting a shared understanding of the design (32).

4.1. Virtual Prototype

AR can be used to create virtual prototypes of products and industrial processes. This can help reduce the need for physical prototypes and, in turn, minimize material waste and energy consumption during the design and testing phase. For instance, Figure 3 shows how BMW Group is harnessing the benefits of AR technology to accelerate their vehicle conceptualization and prototype engineering cycle reducing development time by up to twelve months, spanning from individual vehicle components to intricate production phases and speedy verification of the assembly process (33).

Figure 3: BMW Group leveraging augmented reality in developing digital prototypes in the design and through production phases (33)

4.2. Sustainable Design and Planning

Architects and urban planners play a crucial role in building sustainable cities. architects and urban planners can use AR to visualize and assess the environmental impact of new construction projects. It allows them to plan and design structures that minimize resource consumption and environmental impact. Dembski et al 2020, utilized AR for collaborative and participatory processes to empower the citizens in urban planning and design through the integration of digital twins for the town of Herrenberg in Germany case study. The digital twin integrates various urban data and enables visualization at different scales, providing a comprehensive tool for sustainable decision support (34,35).

4.3. Application of AR in Transportation

AR applications play a crucial role in providing real-time information for public transportation users, helping them find the most efficient, eco-friendly transportation options whilst visualizing the impact of transportation infrastructure on the environment (36,37). These distinctive characteristics of AR can be utilized to raise awareness (38) about sustainable transportation options and encourage individuals to make eco-friendly choices (37). This awareness can also reduce individual car usage and promote the use of public transport, carpooling, and other sustainable means of transportation.

4.4. Application of AR in Agriculture

Farmers can use AR to effectively monitor crop conditions and livestock (39) and optimize resource usage, such as water and fertilizers, resulting in more sustainable agricultural practices. Similarly, AR can enhance precision livestock farming, improve animal well-being and production, support sustainable agriculture (39,40), enhance safety education (41), and facilitate data visualization and analysis in digital livestock farming (39). By integrating AR into farming operations, farmers can benefit from real-time information, improved decision-making processes, and more efficient and sustainable farming practices.

4.5. Application of AR in Healthcare

AR application is also revolutionising the healthcare industry. AR can provide medical professionals with immersive training (42) and simulation tools, allowing them to practice complex procedures and improve their skills in a safe, controlled environment (43,44). For example, AR can be used to provide patients with virtual tutorials on how to properly use medical devices or to show patients how to perform exercises for physical therapy (43). For example, in December 2022, Torbay and South Devon NHS Foundation Trust (TSDFT) as awarded £402,000 grant to co-develop a software application for AR glasses to improve motor function assessments of people with Multiple Sclerosis (45). Research shows that 92% of children do not follow all correct steps when using inhalers (46), the use of AR-enhanced Ashma education has resulted in improvements in knowledge and treatments (46). AR technology has the potential to offer effective visualization of complex anatomical structures within the human body (43). For example, Figure 4 shows how HoloCare enhances the safety and precision of surgery by harnessing AR technology to provide medical professionals with 3D images, thereby improving their spatial understanding of anatomical features (47).

Figure 4: Medical professionals interact with 3D images, gaining a comprehensive view of anatomical features, and adjusting holograms for precise surgical planning (47).

5. Conclusions

AR technology has the potential to advance sustainability practices across various sectors. It can be used to promote sustainability by offering information about a product's eco-friendliness and how to properly manage its use and disposal. Furthermore, its application in precision livestock farming, agriculture, transportation, safety education, and healthcare, amongst others, offers a viable path to improving sustainability. Sustainability is no longer an option but a top priority to mitigate the impact of climate change. Climate change poses a significant challenge to humanity, with far-reaching impacts on various aspects of our lives. Efforts are needed to expedite the transition to a low-carbon economy and bolster resilience against climate change impacts. Collaboration among academia, businesses, governmental bodies, and individuals is crucial for combating the challenge of climate change and promoting sustainability. Further research is needed to assess the effectiveness of technology-driven solutions in promoting sustainability and eco-friendly consumer decisions.

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