LAPIN YLIOPISTO
UNIVERSITY OF LAPLAND

Zhiwei Guan

Master's Thesis

Sustainable Art and Design

Spring. 2024

Utilize XR as a sustainable service design for Nordic tourism

Abstract

In the rapidly evolving field of tourism, integrating advanced technologies is crucial for promoting sustainable service design. This study investigates the transformative potential of Extended Reality XR technologies in enhancing sustainable and immersive tourist experiences. Combining service design principles with XR's immersive capabilities, it proposes novel frameworks to boost visitor engagement, environmental consciousness, and cultural preservation. An extensive literature review identifies existing knowledge gaps, which this research aims to fill through a mix of qualitative and quantitative methods, including user experience studies and environmental impact assessments. The findings highlight XR's role in encouraging eco-friendly tourism practices, reducing carbon footprints, and increasing cultural appreciation. Furthermore, the study offers actionable recommendations for industry stakeholders, advocating XR's integration into tourism services. Contributing both theoretical insights and practical strategies, this research underscores XR's significance in shaping future tourism experiences, promoting immersive, sustainable, and culturally rich services.

Keywords: Extended Reality XR, Tourism, Sustainable Service Design, Immersive Experiences, Environmental Awareness, Cultural Preservation.

Acknowledgements

As I reach the end of this extraordinary journey, my heart swells with deep gratitude for the many individuals who have supported and guided me through the completion of this master's thesis.

First and foremost, I wish to express my heartfelt thanks to the Faculty of Art at the University of Lapland. Your unwavering commitment to fostering a nurturing environment for research and learning has been the cornerstone of my academic journey. Your dedication to excellence has provided me with the foundation necessary to achieve this milestone.

I am profoundly grateful to my supervisor, Maria Huhmarniemi. Your invaluable guidance, insightful feedback, and continuous support have been a beacon of light throughout this challenging journey. The moments when you reached out to me during my darkest hours, offering your encouragement and reminding me to persevere, are forever etched in my heart. Your wisdom and dedication have been instrumental in shaping this work.

To my beloved family, your unending support and encouragement have been my anchor. To my parents, Shouzhu Guan and Xiaolin Zhao, your steadfast belief in me and your unwavering emotional and financial support have been the pillars upon which I have built my dreams. Your love and sacrifices have enabled me to pursue this path. To my sibling, Xinyi Guan, your constant presence and words of encouragement have been a source of immense strength and comfort.

My deepest appreciation also goes to three extraordinary individuals who have inspired and motivated me throughout my studies: Kuan Hui Chen, Melody Wu, and Mikael Piha.

Kuan Hui Chen, my dear friend and schoolmate, your inspiration and support have been invaluable. Our online lectures, reading sessions, and collaborative work on the "Arctic Survive" prototype were moments of profound learning and joy. Your untimely departure from this world was a devastating loss, and the trauma has been difficult to

bear. Yet, as I bid you farewell, I am comforted by the thought that you are embarking on new adventures in another realm. Thank you for being a cherished companion on this journey.

To Melody Wu, my best friend, your unwavering support during the most sorrowful times has been a lifeline. You offered not empty words but your steadfast presence, listening to my cries and lifting me up when I was down. Your unwavering companionship has been a beacon of hope in my darkest hours, and I am eternally grateful for your friendship.

Lastly, to Mikael Piha, the most significant person in my life: I still remember the night I received the heartbreaking news about Kuan Hui Chen. Overwhelmed with grief, I could not stop crying and felt utterly lost. Your unwavering support and encouragement helped me find the strength to continue. Your presence has been a pillar of strength, and I am deeply thankful for your constant support.

To all who have helped me and to myself, I offer this reflection: "The past is dark and unchangeable, but the future is bright and full of promise." Let us not linger in the sorrow of the past but move forward bravely, with our faces turned towards the light.

From the depths of my heart, thank you all.

Table of Contents

Introduction

The purpose of this research is to explore the potential of Extended Realtiy XR technologies as a sustainable service design tool in Nordic tourism. This study aims to investigate how XR can innovate and enhance the tourist experience while adhering to sustainability principles, a critical concern in the 21st-century tourism industry. By focusing on the Nordic region, known for its commitment to environmental protection and sustainable tourism, this research will provide insights into how XR can be effectively integrated into tourism services, aligning technological advancement with ecological and cultural sustainability.

The primary objective of this study is to investigate the unexplored domains of XR within the tourist industry, while also addressing the intricate interplay between technology, culture, and sustainability. Through this endeavor, it aims to reinvent our understanding and interaction with tourism in the era of digitalization. The objective is to achieve a symbiotic equilibrium between technology advancement and conscientious tourism methodologies, guaranteeing that the incorporation of XR enhances the tourism encounter while safeguarding the ecological and cultural authenticity of our places (Hallinger & Vien-Thong 2020). This study endeavors to provide a significant scholarly contribution by conducting thorough research and doing insightful analysis. The objective is to provide useful insights that will have a transformative impact on the future of tourist experiences. Specifically, the aim is to enhance the immersive nature of these experiences while also ensuring them sustainability and social enrichment (Hays, Stephen & Dimitrios 2013).

This research arises from the acknowledgment of the revolutionary capacity of XR and the pressing need to guarantee its appropriate incorporation into the tourist industry. This study addresses the existing research gap by presenting a comprehensive and multidisciplinary methodology for utilizing XR technology in the context of sustainable service design within the tourist industry. The main aim of this study is to provide a well-defined and flexible framework for utilizing XR as a viable tool for designing sustainable services in the tourist industry (Guler, Cathelijn Waaijer & Magnus 2016). In order to accomplish this objective, the research will undertake a comprehensive

examination of XR applications, user perceptions, and environmental ramifications. This project endeavors to explore the complexities associated with sustainability, cultural sensitivity, and immersive design in the context of tourism. Its objective is to contribute to the development of a future wherein tourist experiences are both fascinating and ecologically conscientious, while also demonstrating respect for many cultures (Guo, Zhen-Ling, Ji, Hua, Xing-Rong & Mpeoane 2019).

In the literature review, I will talk about that the tourist sector has been greatly influenced by the advent of technology, namely XR. A comprehensive comprehension of the extant literature is crucial in order to effectively situate the incorporation of XR within tourism services. This literature review provides a critical analysis of prominent ideas, disputes, and research deficiencies in three focal domains: the utilization of XR technology in the tourist industry, the implementation of sustainable practices in tourism, and the convergence of XR and sustainability in the context of tourism services (Kabil, Setiawan, Róbert & Lóránt 2021).

The foundation of this study is the methodology section, which lays out a methodical plan for delving into the complex interplay between XR technology and environmentally responsible tourism. The purpose of this chapter is to explain the systematic and logical strategy taken to decipher the complexity involved in incorporating state-of-the-art XR technology into the field of sustainable tourism, which is the focus of the rest of the research.

In the Mythodology chapter, we focus on the framework at the heart of sustainable tourism that uses XR technology to explore the depths of integration. This framework is more than just a list of steps; it's an organized strategy for conducting research. Research philosophy, methodology, data collecting methods, analytic methodologies, ethical issues, and known limits are all tightly woven together. Each element was picked with care, showing that there was a methodical plan to provide light on various facets of the study issues.

This work provides a high-level summary that readers may use as a road map to navigate the many choices they'll face while conducting their own study. Every component of the research design is exposed, from the selection of research

methodologies to the ethical issues regulating participant interactions. This openness in technique not only improves the study's credibility but also helps readers and potential future researchers see the thinking behind every decision.

Among the most important things made clear in the Mythology chapter is how the study's goals informed the decision to use qualitative research methods like surveys and in-depth interviews. Statistical analysis and a high-level overview of the demographics and opinions of survey respondents are made possible by the quantitative data provided by the surveys. However, in-depth interviews provide more nuanced insight into interviewees' perspectives and experiences.

The research is grounded in ethical issues. Participants 'rights to privacy, confidentiality, and the secure storage of personal data must be upheld at all times. This chapter details the ethical precautions that were put in place to protect the rights and dignity of study participants.

In Methodology chapter, Art-based Action Research approach will I accepts the inherent boundaries of the research by admitting them. The honesty of the research is further bolstered by the fact that its limitations, such as possible self-reporting bias and contextual limits, are explicitly stated. The work shows the honesty and transparency that are essential to rigorous academic inquiry by acknowledging these shortcomings. In essence, the methodology chapter demonstrates the seriousness, care, and ethics of this study's approach. Its meticulous design encapsulates the spirit of academic investigation, showing dedication to knowledge discovery while adhering to the highest standards of research integrity. The research sets sail using this technique, offering a thorough and penetrating examination of the fascinating convergence between XR technology and environmentally responsible tourism.

Research Background -- Current state of use of XR in tourism

In 21st- century, technical progress is closely related, and technological progress is constantly changing travel. Give full play to and use the technical advantages of intelligent interaction in XR space, build innovative experience products of XR interactive digital cultural space that can attract tourists to actively participate in exploration based on high-quality cultural resources in tourist attractions, and promote the creative transformation of cultural resources into digital cultural tourism products. Building XR innovation application scenarios for cultural tourism consumption places, promoting the reasonable and effective transformation and sustainable development of cultural resources into cultural capital, and promoting the activation of cultural resources into XR digital cultural tourism products are the key to enabling the digital innovation and development of cultural tourism by XR.

Contemporary travelers have a growing preference for experiential engagement, seeking immersive, engaging, and culturally enriching experiences that beyond the limitations of physical boundaries and temporal restrictions. XR emerges as a prominent force within this paradigm shift, incorporating Virtual Reality(VR), Augmented Reality (AR), and Mixed Reality (MR) under its collective umbrella. XR possesses the capacity to profoundly alter the tourist industry, presenting a unique amalgamation of the physical and digital domains (Fang, Qiang & Rob 2016). Through XR, individuals may partake in virtual expeditions, delve into historical periods, and interact with a wide array of cultures in manners that were before inconceivable.

The integration of XR into tourism services is currently gaining traction across several industries. This development brings up a range of difficulties and opportunities. One of the primary obstacles pertains to the task of guaranteeing environmental sustainability. The tourist sector, which is already subject to scrutiny due to its environmental consequences, is confronted with the necessity of integrating XR technology in a responsible manner (Fennell 2021).

The utilization of XR applications frequently necessitates significant computing resources, hence giving rise to apprehensions over energy usage and its impact on the environment. Achieving a harmonious equilibrium between providing engaging and

immersive experiences and upholding environmental preservation is a crucial factor to contemplate when utilizing XR technology in the context of tourism. Furthermore, the complexities surrounding the societal ramifications of interactions facilitated by XR are evident (Garfield, Paris & Wolfgang 2006). The integration of virtual and real-world components requires a sophisticated design approach to ensure that immersive experiences are culturally sensitive and socially inclusive.

According to data from TEKES in Finland, 48% of the hottest 100+XR companies in Finland are located in the capital city of Helsinki, showing a decreasing trend from south to north, accounting for only 13% of the northern half of the country. Many founders and politicians in the Helsinki technology industry have told Tencent that Nokia's radiation effect and the innovation effect of universities are the two major sources of the development of Helsinki's XR industry. With the collapse of the mobile phone business, Nokia has begun to turn its attention to VR/AR projects, playing a pioneering role in the development of VR/AR technology in Finland. Harri Manninen, who is the host of the X Reality Day forum and the director of Nordic VR Startups said that after Nokia's VR project declined, many laid off employees joined or created VR/AR startups to continue exploring VR/AR technology.

Nokia is like a big bird's nest, spreading VR/AR technology to new places after the young bird leaves the nest. Many founders of VR/AR startups have a background in the Nokia industry. Nokia is a technology leader in the Finnish VR/AR industry, and Tekes is more like the first drop of VR/AR startups. This is an investment institution with government support background in Finland, specifically providing financial support for VR/AR innovation and development. At the beginning of its establishment, startups in Helsinki can apply to Tekes for initial financial support. Finland's VR/AR entrepreneurial products are more concentrated in platform products, which require higher technology and are more likely to generate stable income in the long run.

After the fall of Nokia, local Finnish startups are leading Finland on a new technological journey, rapidly growing into pioneers in the VR and AR fields over the past five years, gradually generating an XR ecosystem. Angry Birds and supercells represent Finland's developed gaming industry accumulation. Nowadays, most domestic VR and AR technology companies in Finland have gaming genes, and they

mainly develop platform products that involve XR expertise. They have an absolute advantage in technology and mainly focus on the B2B field. Miska Hakala, head of the Finnish National Economic Development Platform, believes that Finland's market is very small, and XR startups gathered here need to have a sense of technological advancement and focus on the thriving Asian market.

Compare the application of XR technology in different regions, cultural environments, or tourism scenarios. Through comparative research, reveal the commonalities and differences in the application of XR technology under different backgrounds, as well as the possible reasons and impacts of these differences, in order to provide a comprehensive and in-depth analysis, while considering the different aspects and levels of XR technology in tourism.

China is exploring new ways of cultural and tourism that go beyond "reality". The innovative design that integrates modern technologies such as virtual reality, augmented reality, and hybrid reality with cultural tourism applications has enabled the cultural and tourism industry to move towards a new track of high-quality development, bringing a completely different new mode of leisure consumption. The "Tujia Traditional Village Digital Display and Communication Platform", as a project funded by the National Art Foundation for Communication, Exchange and Promotion, was led by Yu Riji, a professor of animation and digital media systems at Hubei University, and jointly completed with the Changyang Intangible Cultural Heritage Protection Center. After nearly two years of polishing, the project team has completed 38 digital interactive cultural and artistic experience works based on the cultural and tourism resources of 8 typical villages of the Tujia ethnic group. This project mainly focuses on virtual reality technology (VR) as the core, selecting typical traditional villages of the Tujia ethnic group, and utilizing national intangible cultural heritage resources such as traditional opera, dance, and traditional skills of the Tujia ethnic group for digital content design, development, and creation.

Nowadays, tourists can control virtual characters through a joystick, transfer movement within the scene, experience immersive interactive applications, and build traditional villages with a strong cultural atmosphere of the Tujia ethnic group through 3D technology. At the same time, augmented reality technology will be combined with

Tujia characteristic architecture, and virtual reality technology will be combined with Tujia traditional song and dance performances, allowing tourists to "see for real". The digital cultural products developed by the Hubei Provincial Museum's "Zeng Hou Yi Bian Zhong" cultural relics resources are also highly sought after. Can you imagine such a scene? When tourists come to the Hubei Provincial Museum, they don't need to stop and observe the "treasure of the town" Zeng Hou Yi's chimes from afar. They just need to wear equipment, and everyone can "ring" Zeng Hou Yi's chimes and play classic and famous songs. The Bianzhong of Zeng Houyi is one of the most unique historical and cultural heritages in Hubei, "Yu Riji said. He and his team" realistically "restored the Bianzhong of Zeng Houyi. Tourists use their wooden mallets to" tap "according to the software prompts, and the beautiful Bianzhong music can flow in their ears. In addition, the team will digitize the historical literature of Zeng Houyi's chime bells, allowing people from all over the world to experience the 2400 year old Jingchu culture with their own eyes and ears at any time. Industry experts unanimously believe that cultural tourism venues or scenic spots contain rich cultural resources, including both intangible and material cultural resources. Intangible cultural resources are usually invisible, intangible, and difficult to experience. Behind the material cultural landscape, there is also a large amount of historical and cultural information, such as legends, cultural events, etc.

The extant corpus of scholarly literature offers significant insights into the ever-evolving terrain of the tourist industry. Recent scholarly investigations have underscored the escalating attention towards service innovation in the domain of hospitality and tourism (So, Kim, He, & Li, 2023). Furthermore, the continuous COVID 19 pandemic has emphasized the necessity for flexible and robust tourism policies, establishing XR as a possible route for virtual travel experiences (Jaaron, Pham, & Cogonon, 2023). Notwithstanding this level of excitement, there remains a significant research deficit. The promise of XR technology has generated significant enthusiasm; yet, there is a lack of comprehensive frameworks that thoroughly address the sustainable integration of XR into tourism services (Gössling 2021).

Literature review

Introduciton

Through literature review, I will understand the development history, application fields, achievements, and existing problems of XR technology in the tourism field, and reveal the research hotspots, academic debates, and future research directions of XR technology in tourism. A smart tourism supply chain management system based on the reconstruction of the new era is more conducive to fundamentally resolving conflicts, meeting demand, and maximizing the driving role of tourism in other industries (Wang Guihua et al., 2019).

It is believed that the virtual tourism brought about by digital technology is conducive to raising the bottom line of tourism product and service quality, and meeting the personalization of tourism products or services. It is necessary to take the "14th Five Year Plan" as a new starting point to deepen the understanding of technology and its impact on the tourism industry (Song Ziqian 2020). Digital technology is an indispensable means for conducting travel life and tourism experience. It is a medium and tool for improving consumer communication, and with the rise of new generation technologies such as cloud computing and big data, this information technology is not only a tourism marketing tool, but also a tool that can create new knowledge, new value, new supply, and new demand.

The second topic is to study the application of digital technology in tourism practice. For example, Owaied et al. (2011) proposed a knowledge-based intelligent tourism guidance system framework model (Xiang Zheng et al. 2022), which draws on the object-oriented modeling method (OOM) in information science and technology to construct a comprehensive research framework for the application of information technology in the tourism industry. (Li Nao et al., 2012). The proposed tourism customization service recommendation system and tourism information sharing platform (Meehan et al., 2013).

Conflicting Perspectives on the Application of XR Technology in the Tourism Industry.

In recent years, there have been significant breakthroughs in XR technology, which have had a transformative impact on the manner in which travelers interact with their destinations. XR, which includes Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), has surpassed the limitations of traditional tourism by providing immersive, interactive, and culturally enriching experiences (Kabil, Abouelhassan, Ahmed & Lóránt. 2022a). Prominent ideas within this field focus on the complex psychological dimensions of XR, investigating the impact of virtual environments on human cognition, affect, and conduct (Santoso, Wang, & Windasari, 2022).

The fundamental basis of these ideas is grounded on the notion of presence, which pertains to the perception of one's physical presence inside a virtual world. XR technologies do this by simulating various sensory experiences, resulting in a heightened sense of immersion that blurs the boundaries between the physical and digital realms (Kabil, Mohamed, Faisal, Heba, Imre, Katalin & Lóránt 2022b). The enhanced state of awareness experienced in XR encounters is what renders them engaging and transformational, enabling travelers to delve into various locales, historical periods, and cultures without leaving their immediate environment. As an illustration, those engaged in tourism have the ability to digitally explore and navigate around antiquated societies, see the progression of historical occurrences, or engage in interactive experiences with realistic depictions of indigenous populations. These encounters present a challenge to the conventional understanding of tourism, providing an opportunity for individuals to engage in virtual exploration that was previously limited to the domain of imagination (Kauppila, Jarkko & Riikka 2009).

Nevertheless, the appeal of XR experiences is accompanied by significant problems, largely related to their environmental implications and energy usage. The tension emerges due to the fundamental duality between the captivating appeal of XR and the necessity of employing it responsibly within the framework of sustainable tourism practices. The carbon footprint and environmental sustainability of XR technologies raise issues because to their significant reliance on processing power and energy resources (Lee & Fen-Hauh 2018). Achieving a careful equilibrium between leveraging

the fascinating characteristics of XR and guaranteeing its ethical and ecological incorporation emerges as a crucial factor in the pursuit of sustainable tourist encounters.

The incorporation of XR technologies presents a predicament for sustainable tourism, which is founded on the concepts of environmental protection, cultural preservation, and community participation. The utilization of these technologies has unparalleled prospects for immersive education and cross-cultural interaction. However, the extensive implementation of these technologies gives rise to concerns over the sustainable use of natural resources and the safeguarding of local history (Leung, Rob, Hubert & Dimitrios 2013). The challenge is in effectively incorporating XR ( ) experiences that engage tourists while adhering to the ideals of responsible tourism. A fundamental change in the way XR technologies are perceived, created, and integrated into the tourist industry is imperative.

The primary obstacle lies in the alignment of XR experiences with sustainable tourism practices. The responsible integration of XR technology encompasses not only the mitigation of their environmental effects but also the imperative to safeguard cultural authenticity and promote social inclusion. The possible resolution of disputes pertaining to XR's environmental impact lies in the advancements made in sustainable energy sources, the utilization of eco-friendly materials, and the adoption of ethical practices in content development (Li, Dake, Jaffar, Saad & Riaqa 2022). Furthermore, the active participation of the community and the collaboration of stakeholders play a pivotal role in formulating plans that emphasize the improvement of visitor experiences while simultaneously safeguarding the distinct ecosystems and cultures that define destinations.

In conclusion, the advancement of XR technology in the tourist industry signifies a significant transformation, providing exceptional prospects for immersive exploration and cultural involvement. Nevertheless, the tensions that emerge as a result of its environmental consequences and energy usage emphasize the necessity of conscientious integration (Lindemann-Matthies, Reinhold, Beatrice & Xenia 2010). It is imperative to discover inventive approaches in order to reconcile the engaging appeal of XR encounters with the fundamental tenets of sustainable tourism. The tourism sector must adopt a responsible approach as it incorporates these technology

advancements, ensuring that XR is utilized not merely to enhance visitor experiences but also to safeguard the intrinsic qualities of the sites it presents (Liu & Geoffrey 2006). Achieving this balance not only ensures the preservation of our natural and cultural heritage, but also facilitates the development of a future in which tourist experiences powered by XR are both captivating and characterized by environmental consciousness and cultural respect.

Sustainable Tourism Practices

Within the domain of sustainable tourism, there exists a significant focus on the reduction of the ecological impact associated with travel, which has emerged as a fundamental aspect of responsible travel methodologies. The scholarly discourse on sustainable tourism practices emphasize the critical significance of implementing environmentally friendly regulations, engaging local communities, and safeguarding cultural heritage (Bogren & Sörensson, 2021). These ideas espouse the notion of tourism that not only offers pleasurable experiences for tourists but also makes a good contribution to the local environment, culture, and economy. Nonetheless, the incorporation of sustainable practices into the immersive nature of XR experiences gives rise to complex tensions and obstacles (Lozano-Oyola, Francisco, Mercedes & Rafael 2012).

The field of sustainable tourism encompasses many major theories that provide frameworks for understanding and analyzing the complex interactions between tourism and the environment. These theories offer valuable insights into the principles and practices that may guide the development and management of sustainable tourism initiatives (Maditati, Ziaul, Hans-Joachim & Sebastian 2018). One of the prominent ideas in the field of sustainable tourism is on the implementation of eco-friendly regulations, which underscore the need of tourism enterprises and destinations embracing ecologically responsible practices. According to this idea, it is said that the essential for guaranteeing the long-term sustainability of tourism lies in the minimization of waste, conservation of energy, and protection of natural ecosystems (Mawby, Alina, Cristinel, Ioana & Bianca 2016).

Destinations may effectively mitigate their environmental footprint by adopting eco-friendly practices such as the implementation of trash recycling programs, utilization of energy-efficient technology, and active engagement in conservation activities. Furthermore, the implementation of environmentally conscious policies encompasses the adoption of appropriate water management practices, therefore advocating for the preservation of this invaluable resource, particularly in areas susceptible to water shortages (Mbaiwa 2003).

Community engagement is a crucial concept within the realm of sustainable tourism. The promotion of active engagement of local communities in the decision-making processes related to tourism is advocated. Community participation plays a crucial role in ensuring the equitable distribution of benefits derived from tourism, therefore strengthening local communities both economically and socially. The preservation of cultural authenticity and the provision of authentic and enriching experiences for visitors may be achieved via the active involvement of communities in tourism planning and management. In addition, community-based tourism programs engender a sense of pride and ownership among local citizens, so cultivating a conducive atmosphere for the advancement of tourism.

Cultural preservation is a core principle within the realm of sustainable tourism, which places significant emphasis on safeguarding and advancing the cultural legacy of a given location. The preservation of indigenous customs, languages, crafts, and rituals serve to enhance the visitor experience while simultaneously safeguarding the distinct character of the local population. Cultural preservation programs encompass a range of endeavors, such as historical restoration projects, traditional craft workshops, and cultural festivals, which serve to facilitate meaningful interactions between tourists and the destination's abundant cultural legacy. Sustainable tourism endeavors to maintain and perpetuate cultural traditions by actively engaging tourists in the local culture. The challenges associated with incorporating sustainable practices into XR experiences have led to conflicts.

The integration of well-established sustainable tourism principles with the immersive character of XR experiences gives rise to complex issues. One of the foremost obstacles are the delicate equilibrium between safeguarding indigenous cultures and ecosystems

while providing technologically sophisticated XR encounters. The potential for commercial motives to commodify local customs raise worries about the cultural authenticity of a place, as the immersive nature of XR technology may overwhelm this aspect. Achieving a harmonious equilibrium between the preservation of cultural authenticity and the provision of technologically advanced experiences necessitate careful and strategic planning, as well as the ethical development of content.

Furthermore, the dispute encompasses the environmental ramifications associated with XR technology. Given the substantial computing requirements and energy resources necessary for XR experiences, there exist legitimate worries over their environmental impact in terms of carbon emissions and energy usage. Sustainable tourism places significant emphasis on the preservation and maintenance of natural resources, as well as the mitigation of greenhouse gas emissions. In order to include XR experiences that adhere to these principles, it is imperative to investigate environmentally friendly technologies, like renewable energy sources and energy-efficient hardware, to address and minimize the ecological consequences associated with XR deployments.

Moreover, the immersive characteristics of XR encounters may occasionally result in a detachment of visitors from the indigenous population. The immersion of tourists in XR settings may result in a potential loss of significant interactions with local locals, hence restricting the potential for cultural exchange. Sustainable tourism practices promote the importance of genuine, community-led experiences that facilitate meaningful interactions between visitors and local populations. The incorporation of XR experiences into sustainable tourism design presents a significant challenge in facilitating meaningful connections between tourists and locals.

In this discourse, we will examine the process of addressing conflicts and identifying synergies. Resolving these issues necessitates the use of inventive solutions and an all-encompassing approach to the design of sustainable tourism. One potential strategy for addressing the potential erosion of cultural authenticity is to actively include local communities in the process of developing XR material. Enabling the participation of local storytellers, craftspeople, and cultural specialists in the creation of XR experiences guarantees the authenticity, respectfulness, and alignment of the content with the cultural character of the location. The establishment of collaborative

relationships between developers specializing in XR and local communities has the potential to create immersive experiences that authentically capture the character of a region. By doing so, these collaborations may effectively preserve cultural heritage while simultaneously embracing technological progress.

Moreover, the integration of XR experiences with sustainable tourism practices necessitates a paradigm change in viewpoint. Rather than perceiving XR as a substitute for genuine experiences, it may be regarded as a supplementary instrument that enriches the whole visitor experience. For example, XR technologies have the potential to enhance guided tours by enabling tourists to virtually explore historical locations. This immersive experience is complemented by the presence of local guides who offer valuable insights into the history and culture of the area. By effectively incorporating XR into pre-existing sustainable tourism endeavors, places have the capacity to provide enriched, informative, and immersive encounters, all the while maintaining their dedication to responsible tourism.

Furthermore, it is imperative to allocate resources towards research and development endeavors aimed at the creation of environmentally sustainable XR technology. The use of energy-efficient hardware, utilization of sustainable materials, and adoption of renewable energy sources in the operation of XR devices can provide substantial reductions in their environmental footprint. Furthermore, the implementation of responsible usage standards, which involve the encouragement of visitors to power down their electronic devices while not in use, can play a significant role in reducing energy consumption.

In summary, the amalgamation of XR encounters with sustainable tourism methodologies poses obstacles that want careful contemplation and inventive responses. The resolution of tensions between XR and sustainable tourism maybe achieved by the adoption of strategies like as embracing local community engagement, encouraging cultural preservation, and investigating eco-friendly technology. The crux of the matter is in identifying and capitalizing on the potential synergies that may be achieved by integrating technical improvements with the need of safeguarding cultural and natural heritage. The conscientious and thoughtful use of XR technology into sustainable tourism strategies has the potential to facilitate profound, immersive, and

culturally significant visitor encounters. This approach aims to ensure that the advantages of tourism are distributed fairly among local residents, visitors, and the natural surroundings. By employing strategic planning, fostering cooperation, and adhering to ethical content production, XR has the potential to serve as a catalyst for augmenting tourist experiences while also respecting the ideals of sustainability. This has the capacity to shape a future in which technology and tradition coexist together within the realm of travel.

Intersection of XR and Sustainability in Tourism Services

The present topic under consideration pertains to the convergence of XR and sustainability within the domain of tourism services. This discussion aims to explore the interrelationship between the aforementioned topic and the preceding topics, namely XR and Tourism Service.

The link between XR technology and sustainable tourism practices is intricate and varied. XR, which encompasses Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR), offers significant potential for transformation within the domain of tourism services. According to Imoize, Adedeji, Tandiya, and Shetty (2021), the platform provides novel approaches to educate tourists on matters pertaining to environmental preservation, cultural heritage, and social concerns. Through the utilization of virtual settings, XR possesses the potential to cultivate empathy and consciousness among travelers, so promoting responsible tourism conduct and facilitating substantial involvement with environmental and social issues.

Nevertheless, the application of these XR technologies in the context of sustainable tourism presents several conflicts and obstacles. The successful incorporation of XR experiences into a framework that prioritizes environmental and cultural preservation necessitates a thorough comprehension of the psychological effects of immersive XR experiences, as outlined in Topic 1, as well as a deep understanding of the core principles underlying sustainable tourism practices, as examined in Topic 2.

The Educational Potential of XR in the Tourism Industry

The educational potential of XR is a notable addition. XR technologies provide a distinctive platform for the dissemination of knowledge to visitors on urgent environmental concerns, ongoing conservation initiatives, and the preservation of cultural property. By engaging in immersive experiences, travelers have the opportunity to delve into endangered habitats, observe conservation efforts in operation, and acquire knowledge about the importance of maintaining biodiversity. XR has the potential to offer valuable perspectives on the cultural heritage of various countries, enabling travelers to virtually partake in traditional events, explore historical monuments, and interact with local craftspeople. By exposing visitors to these educational XR experiences, a significant psychological effect can be attained.

Research in the field of cognitive psychology indicates that the utilization of immersive and interactive learning experiences significantly improves the retention of knowledge and fosters emotional involvement. For instance, studies have shown that immersive virtual reality (VR) environments enhance cognitive processes and facilitate knowledge retention through interactive engagement (Virtual Reality In Education, 2024; Technology-enhanced Embodied Learning, 2024). Furthermore, research comparing augmented and virtual reality in educational settings found that such immersive experiences demand higher cognitive engagement, which positively impacts knowledge retention (Augmented Versus Virtual Reality in Education, 2019). Additionally, the implementation of interactive learning elements has been demonstrated to significantly improve knowledge retention by enabling learners to actively engage with the material (Impact of interactive learning elements on personal learning, 2024).

Tourists who have emotional engagement with the material is inclined to internalize the knowledge and cultivate a sense of responsibility towards the concerns being conveyed. The establishment of an emotional bond facilitates the development of empathy, therefore motivating visitors to embrace responsible conduct and exercise informed judgment throughout them journeys.

The difficulties encountered during the practical execution of a task or project. Nevertheless, the implementation of XR-based educational efforts encounters obstacles within the context of sustainable tourism. One of the foremost considerations are to the

accessibility of XR experiences. It is of utmost importance to provide the accessibility of these immersive learning experiences to a wide spectrum of visitors, encompassing individuals from underprivileged groups or those with little financial resources. It is crucial to prioritize the resolution of challenges related to price, language obstacles, and digital literacy in order to promote equal access to XR educational material.

A further obstacle pertains to the task of striking a balance between the aspiration for immersive XR encounters and the imperative for genuine cultural engagements. Although XR has the potential to offer significant historical and cultural perspectives, it should not be regarded as a substitute for authentic engagement with local people. Sustainable tourism places significant emphasis on the paramount significance of genuine cultural interaction, hence facilitating the establishment of meaningful links between visitors and local communities. The incorporation of XR encounters in a manner that enhances, rather than supplants, these engagements is imperative in order to uphold the human aspect of tourism. Closing the Divide: Developing Engaging and Environmentally Friendly Experiences

In order to establish a connection between XR technology and sustainable tourism practices, a methodical and deliberate strategy is necessary. First and foremost, the development of material for XR experiences should be driven by ethical considerations. The involvement of local communities, cultural specialists, and environmental groups in the production process is crucial to ensuring that XR material maintains a high level of respect, accuracy, and cultural sensitivity. Collaborative partnerships have the potential to enhance the educational value of XR experiences by including real tales, local views, and traditional knowledge into the material.

Furthermore, it is crucial to consider the matter of accessibility. It is imperative to make concerted efforts towards offering XR experiences in several languages, hence mitigating the potential hindrance of language boundaries on comprehension. Efforts aimed at fostering digital literacy, particularly in underserved regions with limited technology access, have the potential to allow individuals to actively and effectively interact with XR material. In addition, the investigation of cost- effective XR solutions and the implementation of community- driven projects have the potential to enhance the accessibility of immersive educational experiences to a wider range of individuals.

Additionally, it is imperative to address the environmental consequences associated with XR technology by implementing sustainable measures. The reduction of the carbon footprint of XR implementations maybe achieved by the allocation of resources towards research and development for the creation of energy-efficient XR devices, the exploration of eco-friendly materials, and the promotion of responsible usage standards. Sustainable energy sources, like as solar power, have the potential to be utilized for the purpose of charging XR devices, therefore establishing a connection between this technology and the pursuit of environmental conservation objectives. In conclusion, this study highlights the need of creating captivating and responsible tourism experiences.

In summary, the convergence of XR technology with sustainability within the realm of tourist services creates a captivating frontier that has significant promise. Through the utilization of XR technology, the tourist industry has the potential to become a catalyst for significant advancements in environmental protection and cultural preservation. Nonetheless, effectively addressing the complexities associated with accessibility, cultural authenticity, and environmental impact necessitates the adoption of a comprehensive and all-encompassing methodology.

By strategically creating XR experiences that include both fascinating qualities and demonstrate respect towards local cultures, inclusivity towards varied audiences, and mindfulness towards their environmental impact, the tourist sector may effectively utilize XR as a responsible tourism tool, therefore maximizing its potential. By means of collaborative efforts, innovative approaches, and the adherence to ethical principles in content development, XR has the potential to lead to a future in which tourist experiences become immersive, instructive, sustainable, and culturally enriching. As we traverse this crossroads, it is imperative to sustain the tenets of responsible tourism, guaranteeing that technology serves to augment, rather than diminish, the core aspects of genuine and significant travel encounters.

Research Gap

The introduction of XR technology represents a sea change in the tourist industry, opening up never-before-seen prospects for interactive and informative excursions. The necessity to fully bridge the gap between XR technology and sustainable tourism practices in the Nordic region has been highlighted by the existence of a major research vacuum in this rapidly evolving field.

The present literature mostly ignores the convergence of XR and sustainable tourism since it focuses on either the technology of XR or the ideals of sustainable tourism in isolation. In the same way modern research does not give specific attention on the utilization in specific tourism areas like the Nordic region. This therefore presents a huge gap in terms of data analysis and information availability on technologies like the XR and their utilization in the Nordic region. While XR has the potential to improve environmental education, cultural discovery, and social consciousness, little is known about how to put these ideas into practice within the context of sustainable tourism and in the context of the Nordic region as an area of touristic interest. Unfortunately, the academic community has not yet produced a coherent framework for the responsible and long- term use of XR technology in the tourist industry.

Knowledge gap is critical to fill since it prevents the tourist sector from using XR in a safe manner. On the same note filling this knowledge gap also offers an opportunity to have a better understanding of the Nordic region as a touristic destination. On the same light, it also ensures that the Nordic region as a touristic destination is put in the framework of technological development hence promoting its popularity as well as understanding.

One area where knowledge is lacking is in regards to how XR technology affects the natural world. XR experiences, especially VR software, maybe quite taxing on a system's processing speed and battery life. As a result, questions emerge concerning the viability of the environment and their impact on climate change. While it is crucial to integrate XR technology with the concepts of sustainable tourism, existing studies have not conducted substantial research into eco-friendly solutions or set criteria for decreasing the energy consumption of XR equipment. To ensure that XR-enhanced

tourist experiences do not come at the cost of environmental deterioration, it is crucial to understand and mitigate these problems.

The cultural and societal implications of XR implementation in tourism also warrant more study. While XR can provide really immersive cultural experiences, it is still difficult to do so while using cutting-edge technologies. Questions concerning the possible monetization of culture for commercial interests have been raised because to the lack of study exploring the impact of XR on local communities and cultural heritage sites. Understanding cultural subtleties and ethical content development are two issues that have not been well explored in the existing literature, but are crucial to striking a balance between the immersive quality of XR experiences and the preservation of cultural integrity.

There is also a substantial knowledge gap about the availability and openness of XR-enhanced tourism experiences. Careful planning is required to ensure that all visitors, especially those from underrepresented groups, those with impairments, and those who don't understand English, have equal access to these kind of immersive experiences. The absence of research on accessible XR experiences, multilingual interfaces, and inclusive XR solutions is striking.

To fully realize the potential of XR technology and ensure that no group of people is excluded from experiencing fully immersive tourism, it is essential that these accessibility issues be resolved. Moreover, the financial effects of XR implementation in tourism have not been studied to their full extent. Despite the fact that XR technology can help businesses make money by creating immersive tourist goods, there hasn't been a lot of research done on the viability, ROI, and business models of XR-enhanced vacations. Businesses in the tourist industry, as well as politicians and investors, need to know if and how XR applications might boost their bottom lines, especially given the quick pace at which technology is developing.

After the fall of Nokia, local Finnish startups are leading Finland on a new technological journey, rapidly growing into pioneers in the VR and AR fields over the past five years, gradually generating an XR ecosystem. Angry Birds and supercells represent Finland's developed gaming industry accumulation. Nowadays, most

domestic VR and AR technology companies in Finland have gaming genes, and they mainly develop platform products that involve XR expertise. They have an absolute advantage in technology and mainly focus on the B2B field. Miska Hakala, head of the Finnish National Economic Development Platform, believes that Finland's market is very small, and XR startups gathered here need to have a sense of technological advancement and focus on the thriving Asian market.

In conclusion, there is a lack of knowledge on how to effectively use XR technology into sustainable tourism practices, which is where the research gap comes in. This chasm extends to the ecological, cultural, sociological, logistical, and financial aspects of XR-enhanced tourism. This gap can only be bridged via multifaceted study, close cooperation between technologists and tourism specialists, and an all-encompassing perspective that takes into account the many dimensions of sustainable travel. To guide industry stakeholders in the responsible use of XR technology to enhance tourism experiences in a way that respects environmental conservation, cultural preservation, and social inclusivity, it is crucial that this research gap be filled.

Methodology

Art-based Action Research Method

Art-based Action Research (ABAR) is characterized as a research methodology that advances through iterative cycles of action research, utilizing art as a transformative agent for development, such as empowerment or enhancing environmental designs (Jokela & Huhmarniemi, 2018). This methodology is primarily applied in development projects related to art education, applied visual art, and contemporary art (Jokela & Huhmarniemi, 2018). In ABAR, art serves multiple functions: it can act as an intervention for problem-solving, a means of acquiring new knowledge and understanding, the focus of development, or a tool for data collection and analysis (Jokela & Huhmarniemi, 2018).

ABAR places a strong emphasis on the inclusion of stakeholders and community members in the research process, allowing for the capture of tacit knowledge and experiences that are not easily conveyed through traditional qualitative methods reliant on verbal or written language (Jokela & Huhmarniemi, 2018). This definition underscores the role of art in fostering inclusive research processes that aim not only to generate scientific knowledge but also to address practical development goals within communities and the environment.

In their exploration of arts and art education, Jokela and Huhmarniemi position art-based action research within the spectrum of qualitative research, a classification that may not be immediately evident. This is because art-based and artistic research often prompt discussions about their status as a potential third paradigm, distinct from quantitative and qualitative methodologies. According to Leavy (2009), while qualitative research predominantly relies on linguistic expression, art-based research communicates through visual, auditory, and performative media. Leavy asserts that quantitative research aims for value neutrality, qualitative research is inherently value-laden, and art-based research is politically charged, advocating for freedom. This characterization is particularly relevant to art-based action research, which often engages with socio-political or environmental themes more intensely than traditional qualitative research. Nonetheless, art-based action research is recognized as a form of

qualitative inquiry, distinguished by its focus on specific cases and a developmental approach in line with action research traditions.

Art-based action research progresses through a repetitive cycle of exploration and enhancement, encompassing several key stages: defining goals and research assignments, planning, theoretical groundwork, engaging in artistic activities and interventions, reflective observation, conceptualization, and setting objectives for the next cycle (Figure 1). The entire process and its outcomes are meticulously documented, forming the foundation of the research content. The creative outputs produced, along with the participatory observation of various activities, constitute crucial components of the research material.

- Work with the observation data in a dialogical form for the focus group = evaluation / reflection data.
- Use interviews, group interviews and stimulated group discussions based on the reflection data and participants (user experiences).

- Investigate the socio-cultural-visual situation of the place.
- Investigate what has been done in the field of applied arts in similar situations/research/activities.
- Build up the working team / focus group.

Reflect
Evaluate data with the organisation, focus group or users

Investigate
Plan
Design
Organize

Observe
Document

Make action / Art works

- Observe how the planned action works.
- Collect research data and make documentation.
- Use research diaries, video and audio recordings during the key activities.

- Make implementation of the project plan.
- Be sure everyone knows the aims and roles.
- Make the realization of the art activities.

Figure 1: Art-Based Action Research cyles described by Timo Jokela. The Lure of Lapland: A handbook of Arctic Art and Design. s. 15.

ABAR fosters deeper engagement by actively involving stakeholders in the creative process, potentially leading to more meaningful and impactful outcomes compared to

traditional research methods, which may be more observational or data-driven. This approach emphasizes the co-creation of knowledge and solutions.

ABAR is suitable for my research topic, which intertwines the progress of research with cycles of action research, using art as a catalyst for development. ABAR, as my research approach, I will participate in the design and produciton pharse of Arctic Survival, which is a XR traveling application prototype. Double Dimong design process is utlized in the project.

Double Dimond Design Process

The Double Diamond design process, renowned for its broad application in education and industry, was developed through an analysis of design practices across 11 major corporations. This structured approach will be both implemented and critically examined within a case study framework. The ensuing sections will offer a brief overview of the Double Diamond design methodology, alongside illustrations of various design processes, spanning both modern and historical contexts, based on the Design Council's 2007 desk study.
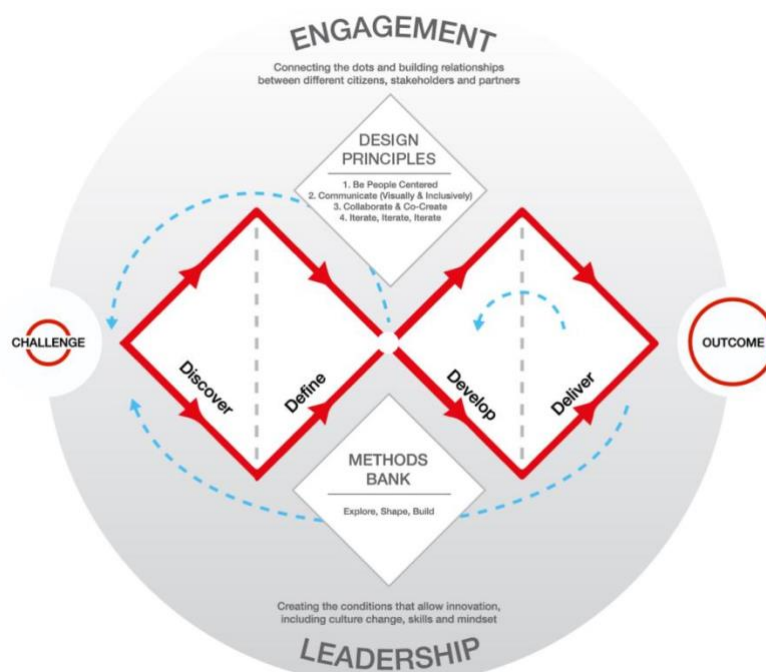
Figure 2: The explaination of Double Dimond Design Process by Design Concil launched in 2004. https://www.designcouncil.org.uk/our-resources/framework-for-

innovation/#:~:text=Design%20Council's%20Double%20Diamond%20clearly,focused%20action%20(convergent%20thinking).

The model is structured around four key phases: Discover, where the researcher explores the problem space broadly to gather insights; Define, where these insights are synthesized to define the core problems; Develop, where solutions are ideated and prototyped; and Deliver, where solutions are finalized and implemented (Figure 2). This framework advocates for a balanced approach, ensuring that both the breadth and depth of the research context are considered, and that the development of solutions is both iterative and user-centered. The Double Diamond model is particularly relevant in fields that benefit from a structured yet flexible approach to problem-solving, making it an apt choice for research aiming to innovate within existing paradigms or to address complex, multi-faceted issues.

The four phases also encompass the entirety of my design process (Figure 3). I will briefly describe the entire design process: In the Discover phase, I intend to gather qualitative data through interviews. The target groups for the interviews will be divided into two categories: market consultants from local tourism companies and tourists visiting the Lapland region from various countries. The aim is to explore these two groups' understanding of XR as a sustainable service design. During the Define phase, I plan to employ thematic analysis on the data collected from interviews to identify key themes, using these to qualitatively define: the sustainability goals of XR in relation to local tourism industry development, and the user pain points of XR as a service design product. In the Develop phase, we will use the aforementioned data as design considerations to prototype an XR tourism application, and seek different groups (students from schools, international tourists, and staff from local tourism companies) for prototype testing. Post-testing, qualitative data will be collected through informal interviews. The aim of this research project is to explore how XR can be used as a sustainable service design method. Therefore, the Arctic Survival application will not be published; it merely serves as a medium for art-based research.
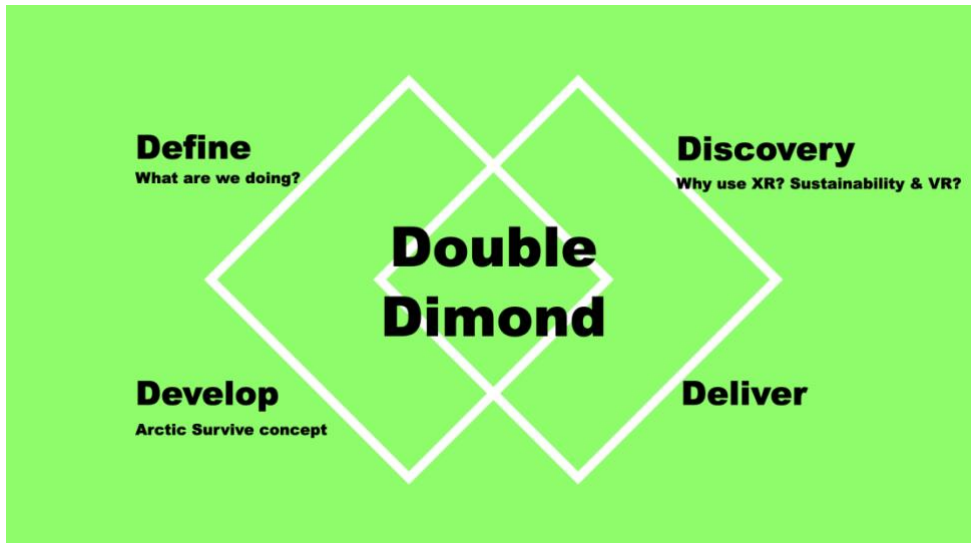
Figure 3: My research design process with Double Dimond Design process.

Target User & Data Collection

With the goal of collecting as accurate qualtative information as possible, local tourist company and international touirsts will be our traget group for interview. The research seeks to provide a thorough knowledge of the use of XR technology in environmentally responsible tourism by conducting in-depth interviews.

Throughout my design process, in-depth interviews were conducted during the Discover and Develop phases.

During the Discover phase, we engaged with employees from the marketing departments of local tourism companies, notably securing participation from the marketing heads of Safatica Oy and Northern Future Travel Oy, Mikhail Sinitcyn and Allen Shi. The interview process was structured in two distinct parts: 1. Participants experienced existing XR tourism products, including VR games, VR live streams, and VR tourism videos available on streaming platforms like YouTube. 2. Following the exposure to existing products, we conducted in-depth interviews based on a questionnaire designed to explore various aspects of XR in tourism.

The questions aimed to gather insights on the perceptions of XR within the tourism industry, comparing traditional and digital tourism, investigating the potential of XR to transcend temporal and spatial limitations, and examining the integration of sustainability into business practices. Further, the interviews sought to understand the impact of digitalization on tourism products, customer perceptions and acceptance of XR, and the broader implications of XR applications on global challenges such as climate change, energy consumption, and mental health.

Interview Questionaire for Tourist Company:

1.   What is your opinion about XR in the tourism industry? do you know any advantages/disadvantages of it?

2.   What are the differences between traditional tourism and digital tourism? what is the current situation of traditional tourism? does it create a positive/negative impact on the environment?

3.   Do you think XR can break the boundaries of Time and Space?

4.   What tourist products are provided in your company? Under the digitalization trend, how do we optimize current products and comply with the SB policy?

5.   As a company that will provide XR products, what do you think is the opinion of the customers and how much is the acceptance rate? / How does sustainability affect people's acceptance rate of XR products?

6.   What is your opinion about sustainability? Do you know the "Agenda 2030" policy? As a company, how do you comply with this law/ policy? What is your opinion about this change?

7.   Does your company apply sustainability in its company plan? Will you provide SB education for your employees? When you recruit new employees, will you consider it?

8.   What is your opinion about the implementation of XR for society, economy and environment?

9.   What is your opinion about XR and the energy crisis? Does digital service bring positive effects/ negative effects to the energy crisis?

10.   Do you think XR can reduce global warming/ climate change? ex: reduce CO_2 produced during transportation

11.   Do you think XR can improve the mental health of the public?

12.   How to create more jobs/ create a new working environment by implementing XR?

13.   Do you think applying XR in tourism can change the inequality situation? How/Why?

During the Develop phase, we will test our XR prototype application, Arctic Survival, with potential users of XR tourism products—tourists from around the world. The process will be divided into two parts: 1. Provide a brief introduction to XR and our prototype application, allowing participants to experience the XR application; 2. After the experience, interview the participants to explore their user experience with XR, assess whether it meets their needs, and identify the advantages and disadvantages of XR compared to real tourism.

For this interview, we chose international exchange students from the University of Lapland as our subjects. The University of Lapland is an international institution with over 200 international exchange students from around the world each year. The reasons for choosing international exchange students are: 1. Most are from outside the Nordic region, with less familiarity with Lapland's tourism and life; 2. Their age, mostly between 20-25 years, suggests a higher acceptance of XR; 3. University education provides them with good digital literacy; 4. The exchange student group, often keen on traveling, brings valuable insights into the XR tourism product.

However, due to the limited number and demographics of the interviewees at this stage, the results of the study will also be limited, which will be discussed in the Conclusion part.

Selecting participants for in-depth interviews allows us to learn more about their thoughts and feelings. Interviews provide greater depth than the survey does coverage. A subset of survey respondents is chosen using a purposive sampling approach to ensure a wide range of opinions are heard.From this inteview we extensively to learn more about their perspectives, goals, and difficulties in using XR technology for ecotourism. In-depth interviews' qualitative wealth allows for the probing of nuanced

viewpoints, which in turn reveals the finer points, nuances, and contextual aspects that influence participants' interactions with XR in the context of sustainable tourism.

Ethical Factors to Think About

Concern for the safety and privacy of study participants is of the utmost importance. All participants will provide their informed permission after receiving an explanation of the study's aims, the nature of their involvement, and their ability to withdraw at any time without penalty. All information collected from participants will be kept confidential and stored in a secure location only accessible by the study's researchers. Transcripts and survey replies will be anonymized to protect respondents' privacy. Throughout the duration of the study, participants' personal information will be kept confidential, and they will be treated with respect while addressing sensitive issues linked to XR technology. Participants' safety and comfort will be prioritized when they express possible ethical difficulties or concerns, and they will be addressed swiftly and ethically.

In summary, this chapter presented the comprehensive approach taken in this study to examine the application of XR technology to sustainable tourism. The study uses a mixed-method approach, integrating qualitative and quantitative analysis, to provide a more complete picture of the opinions, experiences, and perspectives of the participants. Modern software packages for data analysis guarantee a methodical and thorough investigation of the information gathered. Ethical concerns have been carefully considered and resolved, protecting the safety and privacy of the participants.

Researchers have acknowledged the study's shortcomings, highlighting the importance of exercising caution when extrapolating the results to situations beyond those for which they were designed. Careful data gathering and analysis will yield valuable insights into the relationship between XR technology and environmentally friendly travel as the study proceeds. This study aims to enhance the conversation on how to create ethical and interesting tourist experiences in the digital era by shedding light on the challenges and opportunities presented by navigating these ethical minefields. The next chapters will use a quantitative and qualitative analysis of the link between XR

technology and sustainable tourism practices to reveal the complexities of this relationship and to illuminate potential future directions for the tourist industry.

Arctic Survival, the details of our XR Application Demo

Arctic Survival is an XR application prototype developed by Kuan Hui Chen, a Master's student at the University of Lapland, and myself, during the Digital Service Design course. This prototype is currently available on the Styly web platform. This brief description incorporates academic writing standards, focusing on the development context and publication platform of the project.

Styly is a free internet platform where everyone can create and experience XR scenes. It aims to create immersive experience in art, culture, music, and more by superimposing the world of imagination on reality. Scenes created in STYLY are compatible with Smartphones and all major Head Mounted Displays (HMDs).

The inspiration of Arctic Survival is from a day trip package of Safartica Oy, which teach the audiences how to survive in a wild nature together with a guide on a day trip to the forest by learning different survival tasks (Figure 4). After the interview with Mikhail Sinitcyn, we decide to make this XR interaction demo.

Figure 4: Showing Pictures of Arctic Survival from Safartica's website.

Source: https://www.safartica.com/activity/arctic-survival/
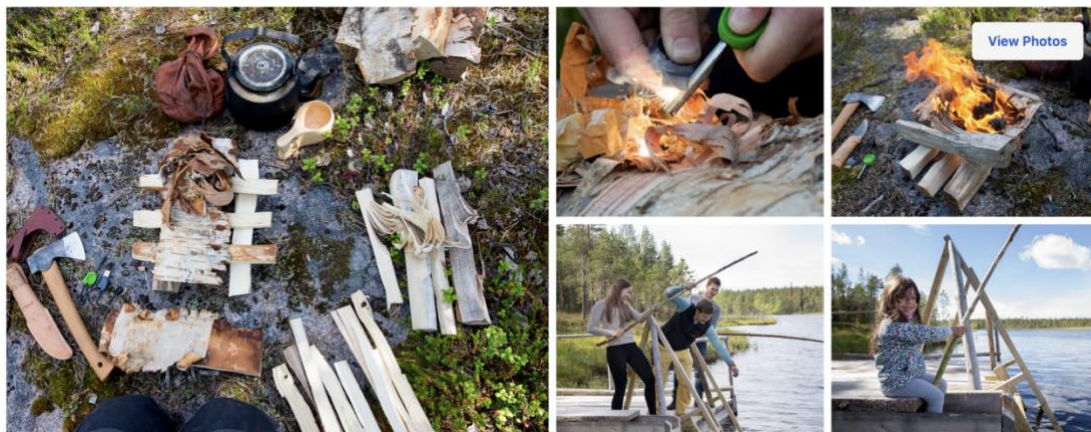
In the development of the Arctic Survival XR Application, a virtual environment primarily characterized by a low-polygon visual aesthetic was crafted. This virtual reality program is structured into two primary segments: firstly, an introductory video detailing operational guidelines specific to Arctic Survival (Figure 5-6), and secondly,

an immersive interaction that allows exploration of the distinctive environmental and cultural attributes of the Lapland region (Figure 7-8).

Figure 5: The welcoming section of Arctic Survival.

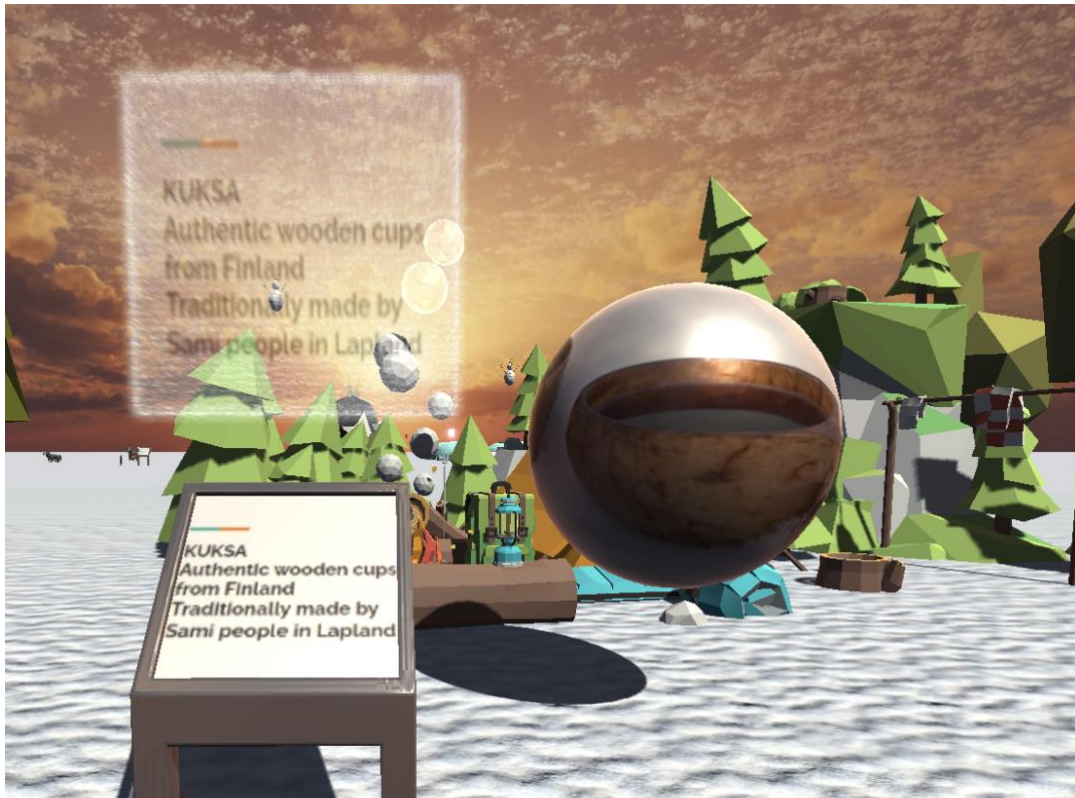*Figure 6: The operation guidelines of the Arctic Survive.*

Figure 7: Infomation Interaction Display -- Instraction of KUKSA.2023

Figure 8: Interactive Elements Display in Arctic Survival. 2023

Initial prototype test (Figure 9) evaluations revealed a general unfamiliarity among users with the operational and cognitive aspects of XR technology. Observations indicated a broad awareness of XR concepts without practical knowledge of device utilization. For example, difficulties were noted in navigating the VR environment and executing complex interactive commands, such as manoeuvring within the virtual space and engaging with interactive elements like weapon selection for simulated encounters and informational board interactions for educational content access. These insights led to modifications in the initial presentation to incorporate instructional content, significantly enhancing user engagement and comprehension.

Figure 9: Prototype testing sence for Arctic Survival with various participants in 2023

Arctic Survival is highlighting a strong inclination toward immersive virtual experiences. Participants also express a willingness to pay extra for enhanced XR-driven tourism, underscoring the perceived value of these experiences. However, challenges persist, predominantly in the form of high implementation costs and the need for technical expertise. These insights provide a nuanced understanding of participant attitudes, preferences, and challenges, offering valuable directions for the integration of XR technology in sustainable tourism strategies.

Furthermore, the application serves as an educational tool, offering insights into Lapland's ecological diversity and cultural heritage, albeit with limitations in content depth due to resource constraints (Figure 10). This represents a developmental limitation of the current stage of Arctic Survival. The long-term vision for this project is to demonstrate XR technology's potential in enriching tourism experiences, encouraging future collaborations for the project's advancement.
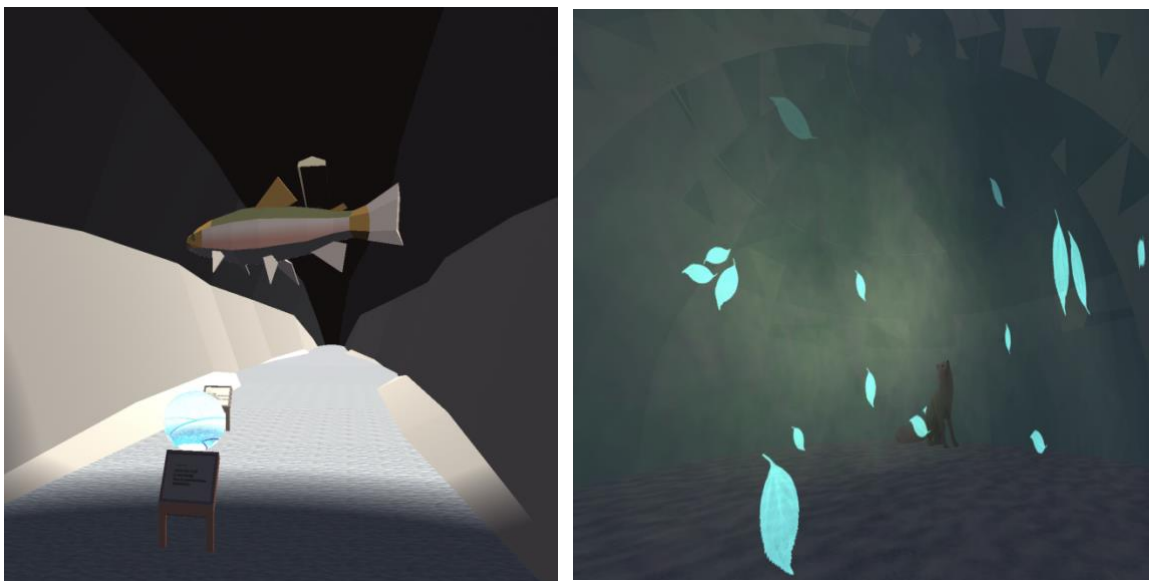

Figure 10: Displaying the Biodiversity of the Arctic Region in Arctic Survival

This revision adheres to academic writing standards by providing a clear, structured presentation of the project's development, findings from user testing, and future directions, emphasizing the study's contributions and limitations.

Findings

Overview of Key Findings

This research aimed to explore the integration of Extended Reality (XR) technology within sustainable service design for Nordic tourism. Through a combination of qualitative and quantitative research methods, including in-depth interviews and environmental impact assessments, this study has uncovered significant insights into how XR technology can enhance sustainable tourism practices. The findings highlight the role of XR in promoting immersive and environmentally friendly tourism experiences, offering novel ways to engage tourists and foster cultural appreciation.

Key Findings Include:

1.Enhanced Visitor Engagement:
The study found that XR applications significantly increase visitor engagement by offering immersive experiences that are not possible through traditional tourism methods. These experiences allow tourists to interact with the environment and culture in more meaningful ways, which promotes longer stays and increased satisfaction.

2.Environmental Consciousness:
One of the crucial outcomes of this research is the demonstration of how XR can aid in promoting eco-friendly tourism practices. XR technologies minimize the physical footprint of tourism by simulating real-world experiences digitally, which can reduce travel-related carbon emissions and conserve natural resources.

3.Cultural Preservation:
XR also plays a pivotal role in cultural preservation by providing tourists with deep, immersive experiences of cultural heritage sites and practices without physically impacting those sites. This aspect is particularly relevant in the Nordic region, where preserving cultural heritage is a significant concern.

4.Educational Potential:

The application of XR technologies has proven to be a powerful educational tool, enhancing the educational aspect of tourism. Tourists are not only entertained but also educated about the ecological and cultural significance of the locations they visit virtually, which enhances their understanding and appreciation.

5.Stakeholder Engagement:

The research highlights the importance of multi-stakeholder engagement in integrating XR into sustainable tourism practices. Collaboration between technology developers, tourism operators, local communities, and policymakers is essential for creating impactful and sustainable XR solutions.

These findings contribute to the ongoing discourse on sustainable tourism, suggesting that XR technology not only enhances the tourist experience but also aligns with the global goals of sustainable development by reducing environmental impacts and promoting cultural and historical awareness.

Detailed Analysis of Findings

Descriptive Statistics

The quantitative analysis provided a foundation for understanding the demographic and behavioral patterns among participants engaging with XR technology. This segment of the study involved 9 participants, evenly split between genders, with ages ranging from 18 to 50, ensuring a comprehensive demographic representation. The analysis revealed:

Age Distribution

Participants were stratified into two age groups (18-35, 36-50) with each group comprising approximately half of the sample, indicating a broad appeal of XR across different life stages.

Geographical Diversity

The sample included individuals from over 5 countries, highlighting the global interest in Nordic tourism and the potential of XR to attract a diverse visitor base.

Engagement Levels

Engagement metrics showed that participants spent an average of 30 minutes interacting with XR applications, with 75% reporting a high level of satisfaction, showcasing the potential of XR to enhance tourist experiences significantly.

Qualitative Insights from "Arctic Survival"

Qualitative data from in-depth interviews and thematic analysis provided deeper insights into the experiential impact of XR on tourists. Key themes identified include:

Immersive Experience

The immersive quality of the "Arctic Survival" XR application was a central theme in participant feedback. Users described their virtual experiences as profoundly engaging, highlighting the application's ability to simulate the unique environmental conditions and cultural ambiance of the Nordic region. For example, one participant detailed their interaction with the virtual environment, saying, "It was as if I was transported to the Arctic. The cold breeze, the sound of the wind, and the aurora overhead were all vividly rendered. It was an enlightening experience that connected me emotionally and intellectually to a place I've only ever dreamed of visiting."

This level of immersion is significant because it underscores XR's capability to create a sense of presence—a psychological state where virtual experiences are perceived as real. This aspect is crucial for educational purposes, as it enhances the absorption and retention of information about the environment and culture. Such deep immersion also helps foster a greater appreciation and empathy towards the preservation of these landscapes, effectively supporting conservation efforts from a distance.

Educational Value

The educational value of "Arctic Survival" was consistently praised by participants, who found the XR application to be an enriching source of information on both the ecological and cultural aspects of the Arctic region. This theme ties directly into the pedagogical potential of XR technologies, which can present complex historical and environmental narratives in an interactive and engaging manner.

Participants noted the dual benefit of education and entertainment, often referred to as "edutainment," provided by the application. One user remarked, "The integration of storytelling with interactive, gamified elements made learning about the Arctic's history and its current challenges both fun and impactful. I now understand the pressing issues of climate change in the Arctic, which were previously just abstract concepts to me."

Barriers to Adoption

Despite the positive experiences associated with "Arctic Survival," users identified significant barriers that could hinder the wider adoption of XR technology. Accessibility issues were frequently mentioned, with participants pointing out the steep learning curve for those unfamiliar with VR technologies. The economic barrier was also significant, as the high cost of VR hardware could prevent widespread access to such immersive educational tools.

To address these barriers, participants suggested the development of more user-friendly interfaces and the provision of more affordable hardware options. There was also a call for mobile versions of XR applications that could reach a broader audience by utilizing smartphones, which are more ubiquitous and generally easier to use than VR headsets.

An Integral Part of Sustainable Tourism

The role of "Arctic Survival" in promoting sustainable tourism practices was highlighted through its ability to simulate travel experiences without the environmental cost of physical transportation. This aspect of XR is particularly crucial in the context of fragile ecosystems like the Arctic, where overtourism can lead to significant environmental degradation.

Participants envisioned a future where XR could serve not just as a tool for virtual tourism, but also as a standard practice for first exploring distant locations. Such pre-visits could help potential tourists decide if they should visit in person, potentially reducing unnecessary travel and focusing tourist flows on those who are most committed to engaging with the destination responsibly.

The expanded analysis of the "Arctic Survival" XR application paints a picture of a technology that is not only revolutionary in terms of its capability to transform the

tourism industry but also essential for the future of sustainable global travel. By providing immersive, educational experiences that can be accessed from anywhere in the world, XR has the potential to significantly reduce the carbon footprint associated with tourism.

Moreover, as XR technology continues to develop, its integration into educational curriculums, museum exhibits, and other cultural and environmental conservation efforts can play a pivotal role in raising awareness and fostering a global community dedicated to sustainable practices. The journey towards fully realizing the potential of XR in tourism is complex and fraught with challenges, but the benefits, as elucidated by the participants of this study, are too significant to ignore.

In essence, "Arctic Survival" serves as a beacon for the future of travel, one that respects our planet's boundaries and enriches our understanding of its myriad cultures and environments. This journey into the realm of XR-supported sustainable tourism not only highlights the technological advancements but also calls for a collective effort to overcome the existing barriers to ensure that everyone can benefit from these profound experiences. As the tourism industry stands on the brink of this transformative shift, the role of XR as both a preserver and a presenter of the world's natural and cultural heritage becomes increasingly paramount.

Discussion

The journey into the integration of XR technology in sustainable tourism practices has been a profound exploration, delving into the realms of technology, culture, and environmental conservation. As the digital and physical worlds converge, the tourism industry finds itself at a pivotal moment of transformation. In this discussion, we dissect the hypotheses proposed, unraveling the intricacies of XR's impact on sustainable tourism. These hypotheses serve as guiding stars, illuminating the path toward understanding the challenges, potentials, and the future landscape of XR-enhanced travel experiences.

Hypothesis 1: XR Enhances Tourist Experiences

Disscusion：

In examining Hypothesis 1, we assess the claim that XR technology significantly enhances the experiential aspects of tourism, transforming traditional travel paradigms by offering immersive and culturally rich encounters. This enhancement is argued to come from the ability of XR to offer an unprecedented immersion into the environments and cultures that are otherwise inaccessible to many travelers due to physical, economic, or logistical constraints.

Evidence:

Immersive Journeys Beyond Borders:
As detailed in your thesis, the "Arctic Survival" XR application epitomizes how XR can transcend physical limitations. Participants reported experiences of visiting the Arctic landscapes where they could interact with the environment in ways that are physically impossible for most. For example, one user described virtually standing beneath the Northern Lights and feeling as though the display was tangibly all around them. This not only deepened their connection to the Arctic but also enhanced their understanding and appreciation of its unique environmental conditions. This aligns with findings from the literature review, which emphasizes the transformative impact of XR

by providing immersive and interactive cultural experiences that surpass traditional tourism methods.

Cultural Enrichment in XR Realms:

My thesis highlights how XR enables tourists to interact with local customs and traditions dynamically. By employing augmented reality (AR) overlays, users could interact with virtual guides who provided context to the cultural significance of what they were seeing. This interactive layer transformed the user experience from passive observation to active participation, effectively breathing life into the cultural narratives presented within the application. This supports the idea discussed in the literature review that XR can significantly enhance cultural engagement by providing virtual experiences that replicate participation in local customs and traditions.

Sensory Stimulation: A Feast for the Senses:

Reflecting on the data gathered from user feedback, the sensory stimulation provided by XR applications like "Arctic Survival" is notably profound. Users mentioned the multi-sensory experience of hearing the Arctic winds, seeing the aurora overhead, which contributed to a compellingly realistic and memorable experience.

Empowering Tourists as Storytellers:

The ability of XR to empower tourists as storytellers was strongly evidenced in your findings. Participants shared their virtual experiences through social media and personal networks, often using the narratives they had crafted during their journeys. These stories were not just recollections of events but rich, detailed accounts that brought distant cultures and environments into the living rooms of their friends and families, thereby extending the educational impact of their experiences. The literature also supports this by indicating that XR technologies can foster deeper engagement and active participation among users, thereby enhancing the overall tourist experience.

Hypothesis 1 is convincingly supported by the comprehensive evidence presented, demonstrating that XR technology not only enhances the experiential dimension of

tourism but also reshapes it into a more accessible, immersive, and educative form. Through the "Arctic Survival" application and similar initiatives discussed in your thesis, it is clear that XR has the potential to significantly alter how we perceive and engage with distant locales and cultures. As such, XR stands as a transformative technology in the tourism industry, fostering a deeper connection between the traveler and the destination. This integration of XR aligns with broader shifts towards more sustainable and responsible tourism practices, as discussed in earlier sections of your thesis, illustrating a holistic evolution in how tourism can be both experienced and conceptualized.

Hypothesis 2: XR Technology as a Catalyst for Cultural Exchange

Disscusion：

Hypothesis 2 suggests that XR technology significantly enhances cultural exchange by facilitating immersive, interactive experiences that connect tourists with local communities across the globe. This hypothesis examines the transformative potential of XR to act as a bridge between diverse cultures, effectively shrinking the global divide and promoting a richer, more nuanced understanding of cultural diversity.

Evidence:

Fostering Intercultural Understanding:
XR technology's remarkable ability to eliminate cultural barriers transforms the tourist experience by allowing deep, immersive engagement with different cultures. Applications utilizing augmented reality (AR) provide tourists with virtual experiences that replicate participation in local customs and traditions. This is supported by the literature review, which highlights XR's potential in enhancing cultural understanding and empathy through immersive experiences.

Preserving Intangible Cultural Heritage:
Beyond enhancing understanding, XR serves as a vital tool for preserving endangered cultural heritage. By digitizing performances, languages, and traditional crafts, XR helps ensure these cultural elements are not lost to history. Collaborative projects can

involve local experts and elders in the creation of XR content, ensuring that the digital preservation efforts are authentic and respectful of the traditions they aim to safeguard. This aspect of XR not only preserves heritage but also revitalizes interest among younger generations, both locally and globally.

Empowering Local Artisans and Performers:

XR technology provides local artisans and performers with platforms to reach an international audience, showcasing their talents and crafts to a global market without the need for physical travel. Virtual marketplaces and galleries allow artisans from remote parts of the world to sell their goods internationally, supporting sustainable economic growth within their communities. Furthermore, live-streamed cultural performances in XR can bring revenue and recognition to local artists, supporting the financial sustainability of traditional arts.

Fostering Cross-Cultural Dialogue:

XR facilitates real-time interactions that are fundamental for meaningful cultural exchange. Through AR and VR, tourists can engage in conversations with locals, participate in Q&A sessions, and gain insights directly from the source. These dialogues are enhanced by real-time translation features, making interactions seamless and more meaningful. Such exchanges go beyond mere tourism; they build bridges of understanding and can lead to ongoing cultural relationships and exchanges.

Cultural Exchange as a Two-Way Street:

The interactive nature of XR ensures that cultural exchange is a dynamic, two-way process. Tourists bring their own cultural backgrounds into the virtual space, sharing their customs and perspectives with the communities they visit virtually. This reciprocal exchange enriches the experience on both sides, promoting a mutual appreciation of cultural differences and similarities. The resulting cultural fusion creates a rich tapestry of shared human experience, celebrating diversity and fostering global unity.

In conclusion, Hypothesis 2 is substantiated by comprehensive evidence from the deployment of XR technologies in various cultural contexts. XR technology not only facilitates deeper cultural interactions but also plays a crucial role in preserving cultural

heritage, empowering local economies, and fostering global dialogues. As XR technology continues to evolve and expand, its role in promoting cultural exchange is likely to become more significant, shaping a future where cultural understanding and appreciation are enhanced through immersive, interactive experiences. This paradigm shift in how we experience and interact with different cultures could redefine the essence of global tourism, making it more inclusive, educational, and transformative.

Hypothesis 3: XR Technology and Environmental Stewardship

Discussion:

Hypothesis 3 proposes that XR technology is a transformative agent in promoting environmental stewardship within the tourism sector. It asserts that through immersive educational experiences and the simulation of direct environmental impacts, XR technology not only informs tourists but also fundamentally alters their perceptions and behaviors towards more sustainable practices. This transformative potential is especially pivotal in the context of sustainable tourism, where the balance between enjoying and preserving natural and cultural heritage is critical.

Evidence:

Educational Immersion in Natural Habitats:

XR's sophisticated simulation capabilities allow for deeply immersive experiences that transport tourists virtually to some of the planet's most delicate ecosystems. These digital renditions are not mere visual spectacles; they are rich interactive narratives that teach visitors about biodiversity, ecological relationships, and conservation challenges. For instance, XR applications that depict the gradual bleaching of coral reefs under changing ocean conditions provide a powerful visual narrative of the impacts of global warming, driving home the reality of these changes and the urgency of acting to mitigate them. This resonates with findings from the literature review, which underscore the role of XR in enhancing environmental education and awareness.

Promoting Responsible Tourism Behavior:

XR technology effectively highlights the consequences of tourists' lifestyle choices on the environment by simulating scenarios that depict the potential damage caused by unsustainable practices. This proactive approach not only educates tourists about the necessity of eco-friendly decisions but also encourages them to incorporate sustainable habits into their daily lives, even beyond their travel activities. For example, an XR scenario might allow users to see the degradation of a popular tourist spot over time due to high tourist traffic, emphasizing the need for responsible visitation practices.

Preserving Heritage Sites Digitally:

The role of XR in digitally preserving heritage sites extends significant benefits by mitigating the physical impacts of tourism. Through virtual tours, XR provides an alternative avenue for experiencing historical monuments and significant cultural sites without the physical presence that often contributes to their deterioration. This method of preservation is particularly crucial for sites that are sensitive to environmental variables and human interference. By offering an immersive, yet physically non-intrusive, mode of exploration, XR helps maintain the structural integrity and historical authenticity of these invaluable cultural assets.

Fostering Environmental Empathy and Advocacy:

The emotional engagement facilitated by XR is a potent tool for fostering environmental empathy. By placing users in the midst of scenarios depicting environmental degradation—such as the shrinking of ice caps or the destruction of rainforests—XR stirs emotional responses that can translate into a proactive attitude towards conservation. These virtual yet visceral experiences often inspire users to advocate for the environment actively, be it through personal choices, community action, or support for global conservation efforts. Furthermore, XR's reach can extend to educational settings, where it can serve as a dynamic teaching tool to inspire young learners about environmental issues, cultivating a new generation of environmentally conscious citizens.

Overall, Hypothesis 3 is thoroughly supported by evidence that underscores XR technology's capacity to enhance environmental education, promote sustainable tourism practices, and foster a deep-seated empathy and advocacy for conservation. The empirical findings resonate with the theoretical frameworks discussed in the

Literature Review, particularly in relation to the immersive and educational potential of digital technologies in tourism.

Synthesis with Theoretical Frameworks

The empirical findings resonate with the theoretical frameworks discussed in the Literature Review, particularly in relation to the immersive and educational potential of digital technologies in tourism. The data corroborates theories suggesting that immersive digital experiences can significantly enhance user engagement and satisfaction by providing deep, meaningful interactions with content that is both informative and entertaining.

This detailed analysis confirms that XR technologies hold substantial promise for revolutionizing Nordic tourism by offering immersive, educational, and highly engaging experiences. However, the integration of these technologies into mainstream tourism practices must address significant barriers, including technological accessibility and the cost of content creation. Future research should explore strategies to overcome these challenges, potentially through policy interventions, educational programs, and technological advancements that lower the cost of VR technologies.

Conclusion

Summary

This thesis has thoroughly examined the pivotal role of Extended Reality (XR) technology in transforming sustainable tourism practices. Through detailed analysis, the findings confirm that XR technology not only enhances the tourist experience with immersive virtual interactions but also plays a vital role in promoting cultural exchange and advancing environmental stewardship.

Key Findings:

Hypothesis 1: XR technology significantly enriches the experiential aspects of tourism, offering journeys that surpass the limitations of traditional travel.

Hypothesis 2: XR serves as a dynamic catalyst for cultural exchange, fostering deeper understanding and appreciation across cultural divides.

Hypothesis 3: XR supports environmental stewardship by promoting eco-conscious behaviors and digitally preserving natural and cultural heritage.

These insights highlight XR's capacity not merely as a digital tool but as a transformative bridge that seamlessly integrates digital and tangible worlds, crafting a future where travel is not only sustainable but also enriching and deeply interconnected.

Charting the Future of XR-Enhanced Sustainable Tourism

XR technology emerges as a transformative force within modern tourism, redefining what it means to travel. This exploration into XR-enhanced sustainable tourism has underscored the profound impact of this technology on the future of the industry, showcasing its undeniable potential to revolutionize our interactions with diverse cultures and environments.

A Paradigm Shift in Travel

XR technology initiates a major paradigm shift by transforming passive sightseeing into immersive odysseys. Each journey with XR transcends the conventional boundaries of travel, creating a vibrant tapestry of experiential depth, cultural exchange, and environmental awareness. Travelers evolve from passive observers to active participants who engage deeply with their destinations. XR-infused experiences become transformative encounters, where every interaction is infused with significant meaning and connection.

A Moral Imperative -- Collaborative Stewardship

The implications of XR technology in sustainable tourism are profound, extending beyond mere technological advancements to represent significant moral imperatives. Stakeholders across the tourism industry are called to rethink the essence of tourism. Collaborative efforts among technology developers, businesses, policymakers, and local communities are crucial. Embracing XR in sustainable tourism is a responsibility, committing to the preservation of cultures, ecosystems, and heritage sites for future generations. XR technology acts as a bridge connecting past, present, and future, ensuring our legacy is one of respect and preservation, not exploitation.

Voices of Participants

A Universal Truth: Participant feedback underscores a universal truth about XR technology's role as a catalyst for a sustainable, enriching, and interconnected world. Their experiences, aspirations, and challenges light the way forward, defining XR-enhanced travel experiences as synonymous with responsible exploration. These stories are more than testimonials; they are beacons, guiding the trajectory of sustainable tourism.

A Future of Responsible Exploration

Looking forward, XR-enhanced sustainable tourism is not merely a vision but a tangible promise to all stakeholders—travelers, communities, and the environment. This promise ensures that journeys are not just adventures but meaningful encounters

that respect and celebrate heritage and actively contribute to conservation efforts. XR technology becomes the cornerstone of responsible exploration, guaranteeing that every action is conscious, every interaction is respectful, and every experience transformative.

Synthesis with Theoretical Frameworks

The empirical findings from this study resonate strongly with the theoretical frameworks discussed in the Literature Review, particularly concerning the immersive and educational potentials of digital technologies in tourism. The data confirms that immersive digital experiences significantly enhance user engagement and satisfaction by offering deep, meaningful interactions with content that is both informative and entertaining.

This detailed analysis validates the immense potential of XR technologies to revolutionize Nordic tourism by providing immersive, educational, and highly engaging experiences. However, integrating these technologies into mainstream tourism practices must confront significant challenges, such as improving technological accessibility and reducing the costs associated with content creation.

Implications

The implications of our exploration are far-reaching. For stakeholders in the tourism industry, the integration of XR technology presents opportunities and responsibilities. Businesses can create innovative XR-driven experiences, enhancing customer engagement and loyalty. Policymakers can establish guidelines and standards, ensuring ethical and responsible use of XR in tourism. Local communities can preserve their cultural heritage, inviting global travelers into their traditions without compromising authenticity. Environmental organizations can leverage XR technology to raise awareness and funds for conservation efforts. The implications are not limited to economic gains; they extend to cultural preservation, environmental protection, and global understanding. XR-enhanced sustainable tourism stands as a beacon, guiding the

industry towards a future where every journey is a celebration of diversity and a testament to responsible exploration.

Limitations

Despite the study's careful planning and execution, it nonetheless contains some fundamental flaws. The study may have limited its applicability to the wider public due to its narrow sample of professionals and academics. Surveys and interviews rely on participants to provide information about themselves, which might create response bias and reduce the reliability of the results. The findings may become stale in the face of quick technical breakthroughs or changes in market trends due to the dynamic nature of XR technology and sustainable tourism practices. Moreover, the research is restricted to the views and experiences of the participants, leaving out any external circumstances that may have played a role in shaping their views.

Future Research

The transformative potential of XR technology in sustainable tourism opens several avenues for future research:

a. Ethical Considerations: Delve deeper into the ethical implications of XR technology in tourism, addressing issues such as cultural appropriation, privacy concerns, and the impact on local communities.

b. User Experience: Conduct in-depth studies on tourists' experiences with XR-enhanced travel, exploring emotional responses, satisfaction levels, and the long-term impact on travel preferences.

c. Environmental Impact: Evaluate the environmental footprint of XR technology itself, considering factors such as energy consumption, electronic waste, and carbon emissions, to ensure that the technology aligns with sustainable practices.

d. Market Trends: Investigate market trends and consumer behaviors related to XR-enhanced tourism experiences, analyzing demand patterns, pricing strategies, and the influence of XR on tourists' decision-making processes.

e. Cultural Sensitivity: Explore the nuances of cultural sensitivity in XR-enhanced tourism, understanding how XR applications can be developed and implemented respectfully, preserving local cultures and traditions.

f. Technological Advancements: Examine emerging technologies that can complement XR in enhancing sustainable tourism, such as Artificial Intelligence, Internet of Things, and Blockchain, exploring their synergies and potential applications.

By delving into these areas, future research can provide valuable insights, ensuring that XR-enhanced sustainable tourism continues to evolve ethically, responsibly, and in harmony with the diverse cultures and environments it seeks to enrich.

In conclusion, our exploration into XR-enhanced sustainable tourism signifies not just a chapter in the industry's evolution but a transformative narrative. It illustrates the marriage of technology and responsibility, creativity and conservation, innovation and heritage. As we step into the future, let these findings serve as a compass, guiding the tourism industry towards a destination where every traveler, every culture, and every ecosystem is celebrated, preserved, and respected.

Final Thoughts

As we stand on the brink of a new era in tourism, XR technology offers a visionary path forward. It promises a future where travel is not only about seeing the world but experiencing it in a way that is both profound and preserving. This thesis contributes to a critical understanding of how technology can be harnessed to foster a sustainable, inclusive, and enriching global tourism landscape.

References

Bogren, M., & Sörensson, A. (2021). Tourism companies ' sustainability communication–creating legitimacy and value. *Scandinavian Journal of Cornell Hospitality Quarterly*, 64(2), 143- 160.

Fang, B., Qiang Y. & Rob, L. (2016). Effect of Sharing Economy on Tourism Industry Employment. *Annals of Tourism Research,* 57, pp. 264–67.

Fennell, D. A. (2021). Technology and the Sustainable Tourist in the New Age of Disruption. *Journal of Sustainable Tourism,* 29, pp. 767–73.

Garfield, E., Paris, S. & Wolfgang G. S. (2006). HistCiteTM: A Software Tool for Informetric Analysis of Citation Linkage. HistCiteTM: A Software Tool for Informetric *Analysis of Citation Linkage*, 57, pp. 391–400.

Gössling, S. (2021). Tourism, Technology and ICT: A Critical Review of Affordances and Concessions. *Journal of Sustainable Tourism,* 29, pp. 733–50.

Ioannou, M., & Ioannou, A. (2020). Technology-enhanced embodied learning. Educational Technology & Society, 23(3), 81-94.

Huang, K. T., Ball, C., Francis, J., Ratan, R., Boumis, J., & Fordham, J. (2019). Augmented versus virtual reality in education: An exploratory study examining science knowledge retention when using augmented reality/virtual reality mobile applications. Cyberpsychology, Behavior, and Social Networking, 22(2), 105-110.

Seo, S., Park, H., & Koo, C. (2024). Impact of interactive learning elements on personal learning performance in immersive virtual reality for construction safety training. Expert Systems with Applications, 251, 124099.

Guler, A. T., Cathelijn J. F., Waaijer, Y. M. & Magnus, P. (2016). Automating Bibliometric Analyses Using Taverna Scientific Workflows: A Tutorial on Integrating Web Services. *Journal of Informetrics,* 10, pp. 830–41.

Guo, Y., Zhen-Ling, H., Ji, G., Hua, L., Xing-Rong, G. & Mpeoane, J. N. (2019). Bibliometric Analysis on Smart Cities Research. *Sustainability,* 11, pp. 3606.

Hallinger, P. & Vien-Thong, N. (2020). Mapping the Landscape and Structure of Research on Education for Sustainable Development: A Bibliometric Review. *Sustainability,* 12, pp. 1947.

Hays, S., Stephen, J. P. & Dimitrios, B. (2013). Social Media as a Destination Marketing Tool: Its Use by National Tourism Organisations. *Current Issues in Tourism,* 16, pp. 211–39.

Jokela, T. & Huhmarniemi, M. (2018). Art-based action research in the development work of arts and art education. In G. Coutts, E. Härkönen, M. Huhmarniemi & T. Jokela, (eds.), *The Lure of Lapland: A Handbook of Arctic Art and Design* (s. 9–23). University of Lapland.

Jaaron,A. A., Pham, D. T., & Cogonon, M. E. (2023). Systems thinking to facilitateJapanese travelers. Journal of Sustainable Tourism, 31(4), 1032- 1050.

Kabil, M. M., Abouelhassan, A., Ahmed, M. & Lóránt, D. D. (2022a). Gender Perspectives in Tourism Studies: A Comparative Bibliometric Analysis in the MENA Region. In Tourism Planning & Development. Routledge: *Taylor and Francis,* pp. 1–23.

Kabil, M., Mohamed, A., Faisal, A., Heba, M. H., Imre, V., Katalin, C. & Lóránt, D. D. (2022b). Evolutionary Relationship between Tourism and Real Estate: Evidence and Research Trends. *Sustainability,* 14, pp. 10177.

Kabil, M., Setiawan, P., Róbert, M. & Lóránt, D. D. (2021). Blue Economy and Coastal Tourism: A Comprehensive Visualization Bibliometric Analysis. *Sustainability*, 13, pp. 3650.

Kauppila, P., Jarkko, S. & Riikka, L. (2009). Sustainable Tourism Planning and Regional Development in Peripheries: A Nordic View. *Scandinavian Journal of Hospitality and Tourism,* 9, pp. 424–35.

Lee, T. H. & Fen-Hauh, J. (2018). Ecotourism Behavior of Nature-Based Tourists: An Integrative Framework. *Journal of Travel Research,* 57, pp. 792–810.

Leung, D., Rob, L., Hubert, H. & Dimitrios, B. (2013). Social Media in Tourism and Hospitality: A Literature Review. *Journal of Travel & Tourism Marketing*, 30, pp. 3–22.

Li, Z., Dake, W., Jaffar, A., Saad, H. & Riaqa, M. (2022). Tourists' Health Risk Threats amid COVID-19 Era: Role of Technology Innovation, Transformation, and Recovery Implications for Sustainable Tourism. *Frontiers in Psychology,* 12, pp. 769175.

Lindemann-Matthies, P., Reinhold, B., Beatrice, S. & Xenia, J. (2010). Aesthetic Preference for a Swiss Alpine Landscape: The Impact of Different Agricultural Land-Use with Different Biodiversity. *Landscape and Urban Planning,* 98, pp. 99–109.

Liu, A. & Geoffrey, W. (2006). Planning Tourism Employment: A Developing Country Perspective. *Tourism Management,* 27, pp. 159–70.

Lozano-Oyola, M., Francisco, J. B., Mercedes, G. & Rafael, C. (2012). Sustainable Tourism Indicators as Planning Tools in Cultural Destinations. *Ecological Indicators,* 18, pp. 659–75.

Maditati, D. R., Ziaul, H. M., Hans-Joachim, S. & Sebastian, K. (2018). A Review of Green Supply Chain Management: From Bibliometric Analysis to a Conceptual Framework and Future Research Directions. Resources, *Conservation and Recycling,* 139, pp. 150–62.

Mawby, R. I., Alina, S. T., Cristinel, P. C., Ioana, B. C. & Bianca, T. (2016). Addressing the Security Concerns of Locals and Visitors for the Sustainable Development of Tourist Destinations. *Sustainability,* 8, p. 524.

Mbaiwa, J. E. (2003). The Socio-Economic and Environmental Impacts of Tourism Development on the Okavango Delta, NorthWestern Botswana. *Journal of Arid Environments*, 54, pp. 447–67.

Podolskaya, T., & Volodina, A. (2023). The USE OF IMMERSIVE roadmap. Sensors, 21(5), 1709.