Extending Nature Access & Engagement through Augmented Reality

Learnings from a proof-of-concept “Nature Builder” augmented reality application

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Foreword

This report was commissioned by Natural England to explore how Augmented Reality technology can be used to support access, engagement, education, and recreation in the natural environment. The report examines the development of a proof-of-concept Augmented Reality application. We aimed to learn lessons and future steps to implement applications to support nature engagement. The report was commissioned due to the increased use of technology and decreased time spent in nature by young people, as well as a reduction in outdoor education in schools, increased urbanisation, and interest in technology to support engagement and accessibility across Natural England.

Executive summary

The use of technology in nature engagement and education is a recently emerging research trend (Alakärppä et al., 2017; Boyce et al., 2014). Innovative applications of digital technology have been delivered through other venues, such as cultural heritage sites, museums, and classrooms (Moorhouse et al., 2019; Outer Hebrides Tourism, 2023). This project explored the potential applications of augmented reality (AR) to enhance nature-oriented engagement and educational experiences.

AR was experimented with due to the increasing interest in extended reality (XR- a broad term encompassing AR, mixed and virtual reality (VR)), the accessible implementation through mobile devices, and young people spending more time engaging with technology compared to the outdoors (Office for National Statistics, 2017). Additionally, it was suspected that prompting children to explore nature through technology would be relevant in our technologically saturated cultural environment (Damala et al., 2008). This report aims to present the process used to design and develop an AR application proof-ofconcept, considerations, and recommendations.

Several sources of inspiration were explored for the design process, including children's literature on nature education, existing nature education mobile applications, expert interviews, and content from BBC Soundbites. The design decisions included creating an application which leveraged a low-fi, accessible design and maintained ecological authenticity for the natural environment of the United Kingdom. The development team pursued two routes for implementing the two proof-of-concept designs using two separate software packages within the overarching design ethos. The first, Zappar software, was a pre-packaged AR-experience development tool, and the other leveraged the AR Foundations development package available in Unity3D.

Throughout the design and encoding of the proof-of-concept, both approaches achieved different engagement opportunities and varying design goals. For instance, the Zappar version can support fewer features but is easily customisable (Salcedo-Viteri 2020) which could be suitable for multiple engagement opportunities along a nature reserve trail. In contrast, the Unity3D app version is more visually immersive, but it cannot be rendered on all devices. It may be suitable as an empowerment tool for young people to explore rewilding their urban school grounds (Messaoudi et al. 2017; Singh et al. 2022).

For future projects, extended research time (6-9 months) would be well-invested in codesigning and co-producing with desired audiences to fully achieve an engaging user experience and learning/ engagement goals. Alternatively, researching the code base for existing popular AR applications which could be adapted and repurposed by an experienced developer could save resources. These approaches will increase retention and long-term usage (Deng et al. 2010; Kujala et al. 2011).

The learnings from the proof-of-concept build can be tailored to engage new and younger audiences with nature engagement experiences in urban and rural settings; whether that be to empower young children to design a rewilded urban area, engage audiences in

nocturnal or hard to spot fauna, or encourage visitors to walk along nature trails within a nature reserve to limit recreational disturbance.

Nature engagement AR applications can play a pivotal role in engaging new audiences by utilising the following strategies:

Interactive Learning & Encounters: Design AR experiences that offer educational value by providing information about the flora, fauna, ecosystems, landscape, or historic environment present in these settings. Users can learn about the environment, fostering a greater appreciation for nature and virtually engage with nocturnal or rare species as well as foster a holistic appreciation of the area.

Gamification: Introduce gamified elements to make the experience fun and engaging. Incorporate challenges or scavenger hunts that encourage users to explore and learn about their physical surroundings.

Geo-tagging and Wayfinding: Use AR to provide users with navigation assistance in rural settings. Offer maps, trail markers, or location-based information to help users find their way and discover points of interest while also encouraging visitors to stick to paths in areas that may be under pressure.

Storytelling: Craft immersive stories or narratives that take users on a journey through nature. This can help create an emotional connection and deeper engagement with the environment.

User-Generated Content: Enable users to contribute to the app by sharing their own discoveries, photos, or observations. This builds a sense of community and encourages exploration and can encourage community participation and stewardship of these natural spaces.

Seasonal Changes: Highlight the dynamic nature of the environment by showing how it changes with the seasons. Users can witness the beauty of nature throughout the year.

Accessibility: Ensure that the AR app is accessible to people of all ages and abilities. Consider features like audio descriptions, text-to-speech, and compatibility with assistive technologies.

Co-development: Co-designing and co-producing with desired audiences to fully achieve an engaging user experience and learning/ engagement goals will likely increase retention and long-term usage.

Feedback: Allow the local community to provide input and feedback on the AR app's content and features. This can help tailor the app to local needs and interests.

Engaging new audiences with nature in both rural and urban settings requires a thoughtful blend of technology, education, entertainment, and community involvement. By creating AR applications that align with these principles, you can encourage people to connect with and appreciate the natural world in their surroundings.

Contents

Project Background

Children today face challenges connecting their lives to the natural world. This is especially true of children raised in urban environments (Davis & Jones, 1996; Freeman & Tranter, 2011; Kimbell, Schuhmann, & Brown, 2009; Mann et al., 2022; Miller et al., 2021; Sipe et al., 2006). Young students in urban contexts often lack a sense of appreciation for the natural world simply because they do not experience it as much as children living in more rural settings (Clements, 2004; Dietze & Crossley, 2000; Kellert, 2005; Louv, 2005; Louv, 2009; Rivkin 1995).

Moreover, in recent years, young people are spending more of their leisure time on technology instead of engaging with the outdoors (Office for National Statistics, 2017). Yet, exposure to nature, particularly in public green and blue spaces, is associated with numerous health and well-being benefits, including better cardiovascular and respiratory health, improved immune and cognitive function, a lower risk of disease, reduced stress, and supported educational attainment (Chawla, 2020; Fyfe-Johnson et al., 2021; Jimenez et al., 2021; Johnstone et al., 2022; Martínez et al., 2017; Ribeiro, 2021; McCurdy et al., 2010; Overholt, 2012; Wood & Smyth, 2020).

Meanwhile, research on educational technology has been increasing rapidly over the past two decades (Chen et al., 2017; Kesim & Ozarslan, 2012; Lee, 2012; Wu et al., 2013), and successful augmented reality (AR) education projects have received positive reviews in museum, cultural heritage sites, and classroom settings (Dieck & Jung, 2017; Radu, 2012; Sim et al., 2018). The work explored how new technologies, such as AR, could be creatively leveraged to encourage nature engagement and increase interest in the outside world.

Prior AR Research Insights

Nature-based Education and Augmented Reality Review

Previously, a review of nature-based education and utilisation of AR was carried out (see Jani et al., 2023 for full report). In summary, AR can be incorporated into natureengagement and education opportunities through various approaches. However, regardless of the specific format, setting, or subject in which they are employed, several fundamental questions to guide decisions should be considered regarding the introduction and implementation:

- Which learning or engagement outcomes can be better achieved and impacted by these approaches?
- Will audiences be capable of effectively using and engaging with these methods?
- What contextual factors, such as frequency and duration, must be taken into account?
- Is support required for staff and audiences to ensure effective engagement with these tools?
- What constraints need to be addressed, such as time, budget, or suitable spaces?

When using AR to support engagement, recreation, access and education, it should enhance, not replace, the nature-based experiences. AR should present nature in new and innovative ways, offering people novel engagement opportunities, such as exploring different scales or time periods that would be otherwise inaccessible. When introducing a new initiative to explore or promote engagement, recreation or access to natural green (e.g. urban parks, fields, forests) or blue spaces (e.g. ponds, rivers, canals), baseline information will be required before implementing the new initiative to understand the impact.

Technology Reluctance & Concerns

Introducing and utilising technology such as AR into new settings can bring numerous benefits, but it also raises concerns around distraction from the authentic experience. It is essential to carefully consider these concerns to ensure that the integration of technology enhances the visitor's experience rather than detracts from it which has been identified in previous work in art contexts (Aitamurto, 2018).

Concerns and objections about communicating learning or engagement goals and general resistance from practitioners to utilising digital solutions has been identified in previous work when introducing an augmented reality application into a museum gallery. Concerns had been raised by curators while developing an application to help museum visitors visualise missing elements of a fragmentary Roman statue. Museum curators initially resisted the implementation of AR because they were concerned that the introduction of digital technology would detract from viewing. In response to these concerns, the museum app was designed to enhance the visitor’s experience of an object and encourage close looking. This goal was accomplished by leveraging the photography function of camera phones and the Microsoft HoloLens to focus on details of the artwork which might not be noticed without the aid of an expert (Hunsucker et al., 2018).

Informed by this and using AR-based image prompting, consideration should be given to encourage audiences to explore the outdoors and ask questions while using the application; while not detracting from connecting with the natural world.

Design ethos

The primary goal of the proof-of-concept design was to explore avenues to create simple AR experiences for nature-engagement without detracting from the natural environment, and encourage the users' access, engagement, and connections with nature (Billinghurst, 2002; Maynard, 2007). It was further hoped that the strategic use of technology could support teachers in the classroom to engage with outdoor education in urban settings (Lu & Liu, 2015; O’Brien, 2009; Tilling, 2018) or engage and empower young people to visualise

rewilding their local areas or school grounds (Architecture Design Scotland, 2012), as well as augment nature experiences in green and blue spaces for visitors.

Overall, the design ethos aimed to develop a proof-of-concept to engage unengaged young people who experience a decline in nature connection from the age of 10 years (Richardson et al., 2019), especially for children in an urban environment who may not have access to green spaces (Richardson et al., 2019; Markevych et al., 2014; Prellwitz & Skär, 2006; Pyle, 2002; Skär, 2000). Consequently, the design approach aimed first to explore this age group's mental landscape and culture. Therefore, research began by exploring existing engagement publications, activities, and applications, interviewing experts in nature education, and creating a proof-of-concept prototype. The design team envisioned that this initial design could support future user tests and semi-structured interviews with young people and guardians.

Design Research

The proof-of-concept app aimed to engage young people between 7 and 12 years of age due to this age group experiencing the initial decline in nature connection, decrease in outdoor education in school years and increased opportunity to engage with technology (Office for National Statistics, 2017; Richardson et al., 2019). The content and approach for the proof-of-concept Nature Builder AR mobile application was inspired by four outlooks that were aimed towards engagements with children:

- Child-focussed publications and educational engagements
- Existing nature education applications in the Google Play Store and Apple AppStore
- BBC Soundbites
- Expert interviews

Child-focussed Publications & Engagements

Characteristics of interactivity, colourful, engaging, relatable and educational content, and use of simple language were recognised in child-oriented publications, which were identified through an online search and a survey conducted at local bookstores in Oxford. Mature education publications tended to prompt children to go outside and create opportunities to ask thought-provoking questions about why a natural process operates in a certain way.

In addition to physical books, the design team explored child-centred signage installations and activities in various learning contexts, such as the Ashmolean Museum, the Natural History Museum, and the Weston Library. A key observation was that students often engage with small-scale, low-key installations in the galleries, especially if they can see secret drawers or engage directly with precious artefacts.

Existing Nature Engagement Applications

In addition to examining physical publications and engagements, the design team explored and tested existing digital mobile applications in the Google Play Store and Apple AppStore such as AR Landscaper (AR Critic, 2019; EnsenaSoft, 2020), Pollinators AR (Immersive Kid LLC, 2021), and StarWalk (Vito Technology Inc., 2008). Similar characteristics to publications and physical engagements were identified. Popular applications included a gamification element with a clear goal to pursue or a perceived learning benefit for longterm return to the application (see Figure1 and Figure 2).

Figure 1: Screenshots from mobile applications that promote nature education, such as Landscape-AR, PollinatorAR, and StarWalk. Copyright and Image Credit: Nightsky, Utilities, and Immersive Kid LLC.

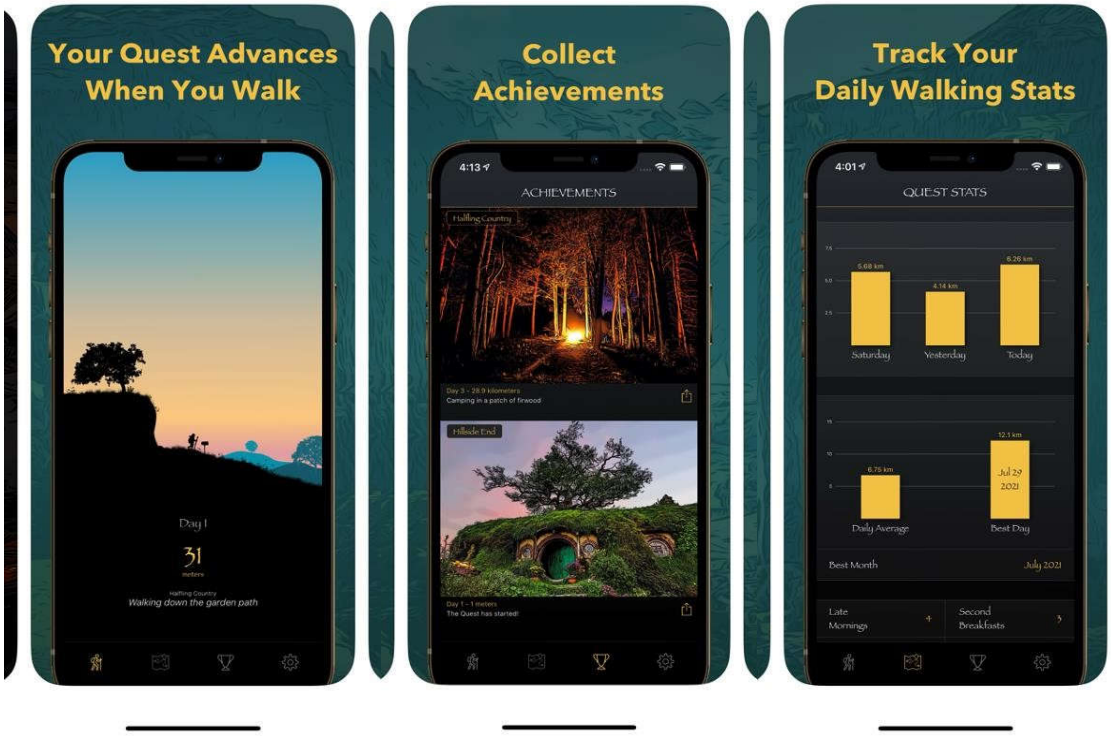

Figure 2: Inspiration for return stats, goals, and data integration from Apple Health. Copyright and Image Credit: the "Fantasy Hike" application developed by Forge7 AB.

BBC Soundbites

BBC Soundbites (BBC, 2023) was identified as a popular educational tool online. The soundbites provided short, concise communication of complex concepts. The content, communications style and language are also designed for a specific level of students across different school learning stages within the United Kingdom. Common characteristics that were identified in the other content reviews of publications, physical engagements and applications were also mirrored here.

Expert Interviews

Building upon preliminary research into children's literature and existing nature applications, the design team interviewed several subject matter experts:

1. School educators
2. Nature-based learning and engagement experts
3. Child and nature engagement XR developer

An anonymised summary from these interviews are outlined below.

Negative views from experts:

- Concerns about adopting digital technology to encourage children to connect with nature. This concern seemed to originate from a belief that technology opposes nature, and that technology can often detract from nature.
- Experts wanted to create more learning resources for children to connect with nature. However, at least for educators, this was coupled with a realistic assessment that, given a few spare hours in the week, they would likely not be able to develop a custom aspect of an AR application- even using the most basic technology.
- Concerns about variations in digital literacy impacting the ability of different users being able to use all of the features of the digital technology.
- Concerns about how to integrate novel digital technology into existing curricula, including the training needed for teachers or outdoor educators to be able to do so without too much extra effort.
- Concerns about technology removing the opportunity for the senses of sound, touch, sight, and smell to connect fully with nature.

Positive views from experts:

- Enthusiasm for utilising technology to engage those who do not already engage with nature.
- Enthusiasm for utilising technology as an opportunity for people in urban environments to engage with nature.
- Experts expressed the positivity of utilising technology to supplement nature engagement opportunities, particularly for individuals that may not have the social or physical means to engage with the natural environment.
- Interest for utilising technology to reconnect young people that have become disconnected or uninterested from nature as they get older.
- Experts expressed positive opportunities for supporting physical activity and wellbeing, as well as an opportunity for enhancing interest in species, as achieved with Pokémon GO.

Design Approach

Based on the initial research, the design team selected a low-fidelity or “low-fi” design for several reasons, including:

1) It visually aligned with identified engagement characterises for a younger audience

2) Accessible to a wide selection of devices

3) Popular games for young and broad audiences (including children and adults) often opt for a low-fi design to increase visual and artistic appeal, such as Minecraft (Mojang Synergies AB, 2009) (see Figure 3).

One of the primary objectives of the design process was to choose 3D assets (digital files) that would yield optimal performance on most mobile devices. Mobile devices are typically not equipped with high-resolution 3D rendering capabilities. A low-fi design, therefore,

enhances the accessibility of the tool by prioritising performance and enabling users to place more 3D assets in their scene. It would be expected that younger users would be more comfortable and less distracted when using an app whose graphical fidelity is secondary to the overall gameplay experience. In short, the aim was to harness the benefits of a simple, stylised design to convey essential aspects of engagement or learning goals whilst minimising device performance risk to broaden accessibility to a broad user base and not detract from surroundings.

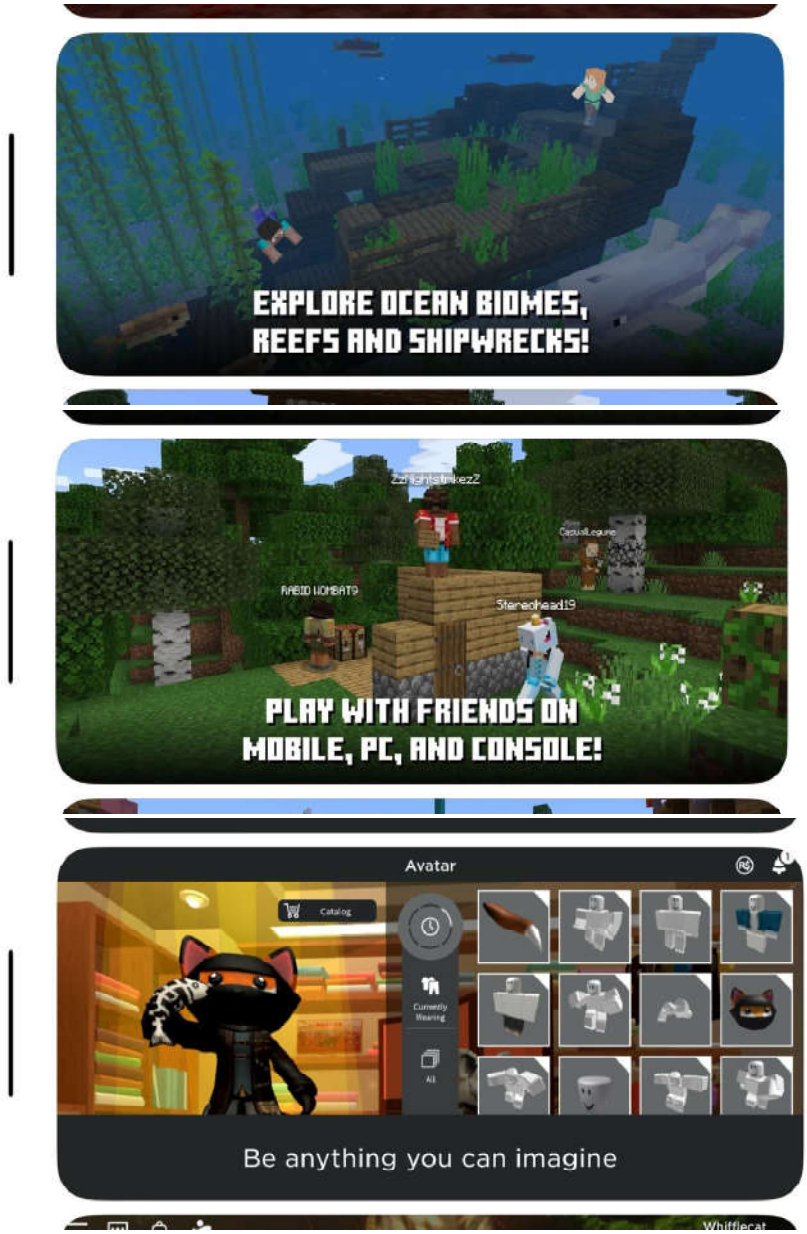

Figure 3: Examples of a "low-fi" design in Minecraft and Roblox. Copyright and image credit Mojang Synergies and Roblox Corporation

AR Technology & Design

Two different proof-of-concept versions were explored using different tools. The dual-platform design choice ensures the application's usability, no matter the user or platform. Therefore, one design route was developed in Unity3D, while another was developed in Zappar (Salcedo-Viteri & Espinoza-Celi 2020). The decision to explore both platforms demonstrates the different AR offers and the potential benefits of an easily adaptable app, depending on the learning goals and nature-engagement experience and setting.

Unity 3D

Unity is a widespread and popular tool used by augmented reality developers, but is not limited to AR. Using Unity3D, a developer can generate everything from fully functioning platform games with lifelike graphics, cutting-edge AR experiences (e.g., Microsoft HoloLens (Microsoft, 2023), and simple 2D phone games. It is a cross-platform gaming engine software fully customisable by the developer in C# (a high-level coding language that helps deal with visual elements and spatial commands) (Unity Technologies, 2023b).

Unity has a large community of developers as well as documentation, tutorials, and forums to support developers in learning and using the engine effectively. Additionally, Unity has an extensive Asset Store where developers can purchase or download assets, tools, and plugins to enhance their projects. This helps speed up development and provides access to a large community of developers and resources.

Zappar

Zappar is a dedicated platform for AR development for mobile devices and web applications. It allows users to log in to a website, upload a 3D model, and instantly get AR working. Its ease of use enables it to be quickly learned and utilised by young audiences and individuals with minimal coding skills. Zappar provides templates and tools and offers tracking features for interactive AR experiences.

Zappar was explicitly selected to explore the possible types of engagement-specific adaptations. For instance, an outdoor educator might customise an exploratory game for a particular exercise. Alternatively, a nature reserve could customise an experience designed to engage with a visitor along a trail walk.

Ecological Authenticity

Given Unity3D is a powerful development engine and platform, the Unity proof-of-concept design opted for multiple 3D assets to be available on a tablet AR experience, while Zappar was available via a basic smartphone for single 2D assets. The proof-of-concept design involved a nature building re-wilding angle of flora.

To ensure nature engagement and educational impact, ecological authenticity of the 3D assets (digital files) was prioritised. Utilisation of premade 3D asset packs which can be customised was explored to ensure ecological authenticity of application as well as limit constraints of time (Figure 4). The customisation process was carried out with strict adherence to the performance constraints imposed by mobile AR. This choice ensured an authentic experience for users and related to native British flora.

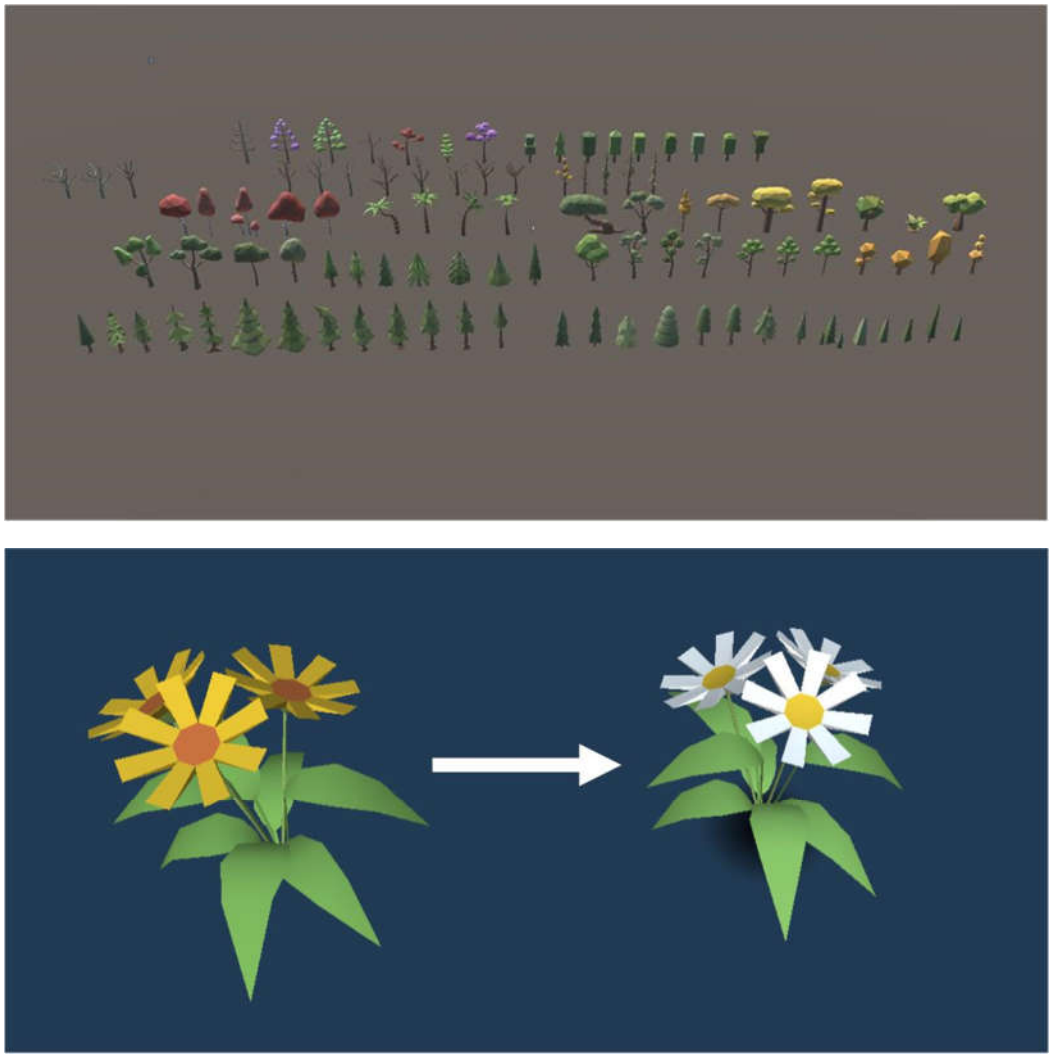

Figure 4: Screenshots of the application's customised and low-fi design assets. Image Credit: Richard Smith and Licence: Standard Unity Asset Store EULA (Available: https://assetstore.unity.com/packages/3d/environments/3d-low-poly-100trees-200885 and https://assetstore.unity.com/packages/3d/vegetation/flowers/lowpoly-trees-pack-flowers-178576)

Proof-of-concept Designs

The design team created an application proof-of-concept idea based on the initial design research and selected approach that can be transferable to future technology-nature engagement initiatives. The idea was to develop an application that would allow the user to build a virtual greenspace indoors or outdoors as a rewilding opportunity and learn about native flora and fauna with prompts to engage with the physical environment. The route was selected due to the ease of implementation using existing commands in native AR libraries which are transferrable learning points; the simplicity of the design relative to the identified

characteristics for desired audience and user needs; and the potential for future aspects of the design which could then build on the proof-of-concept version.

Two proof-of-concepts nature builder AR applications were created. One on Unity3D and the other on Zappar.

Unity3D proof-of-concept

The Unity version of the nature builder AR application features a simple, low-fi 3D userinteraction design (Figure 5). The application opens via a link which can be downloaded via a build file physically stored on a user's device. The icons, text and language are simple and engaging. The colour pallet is bright but ecologically authentic. There are options to insert various flowers, bushes, and trees into the virtual scene. The user can place multiple objects within a single location and can change the size of object as well as walk around the physical environment and view the design from different perspectives. The user interaction design and content can also be edited on a Mac or PC in the "Unity3D" application.

The development team used the AR Foundations package and an example application (GitHub, In., 2023; Unity Technologies, 2023b). However, the development team found the documentation scarce, particularly for the latest version (Unity Technologies, 2023c). The vocabulary and grammar for calling various critical scene components had changed in the code base (Unity Technologies, 2023d). While it was possible to replicate an existing example, it was unclear how to adapt it to the desired features to represent native flora and so a specialist was required for the coding before the initial proof-of-concept build was successfully deployed to a Samsung Galaxy Tab S8 tablet.

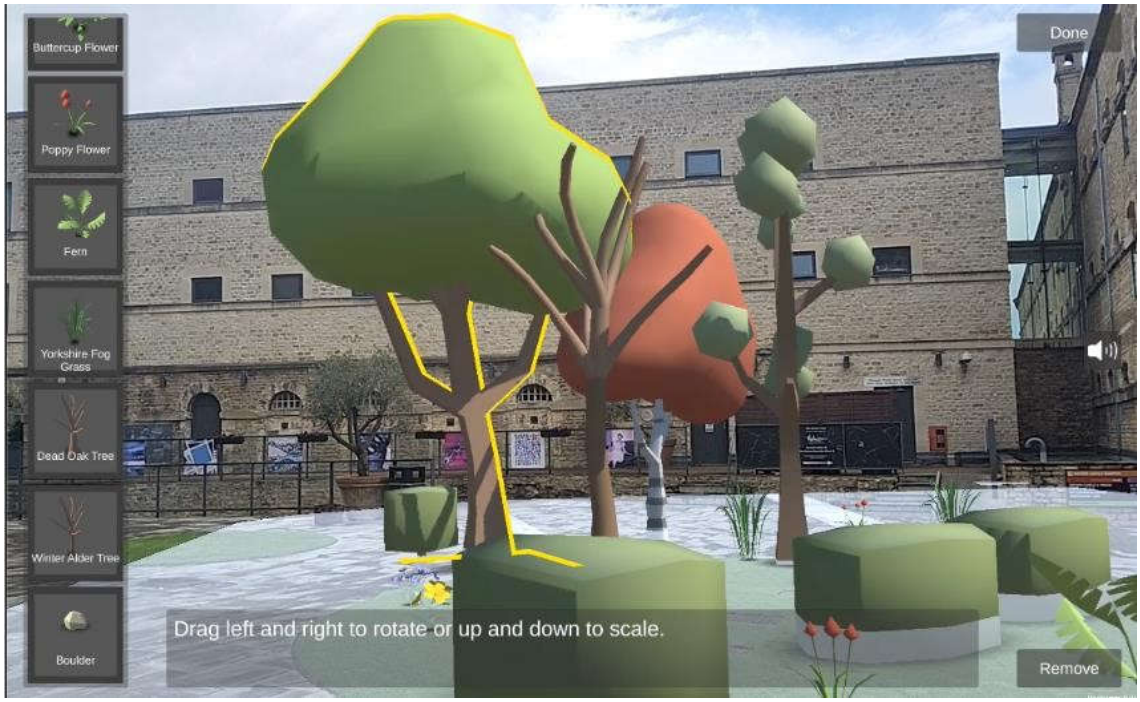

Figure 5: Screenshots of the proof-of-concept AR application in Unity3D. Image and video credit: Richard Smith.

The Unity proof-of-concept app .APK file is available to request from Google drive should someone in Natural England wish to load it onto their own android device manually at their own risk: Access request

Zappar proof-of-concept

The Zappar version of the proof-of-concept nature builder AR application features a simple 2D user-interaction design (Figure 6). The application opens on any mobile web browser via a “ZapCode” (similar to a QR code), which can be printed or displayed on screen. Accessing the app involved downloading the “Zap Works” App to your Android or Apple device, opening the app, click the upper lefthand menu and “Scan Zap” before then scanning the Zap Code (Figure 7).

The icons and text are minimalist. There are options to insert a flower, a bush, and a tree into the virtual scene one at a time. Photographing and saving the background to your phone or completing a user experience survey is also possible. The scene and user interaction design can be edited on a Mac or PC in the Zappar application.

Development documentation was readily available throughout the process for the Zappar proof-of-concept build. However, some features were not easily accomplishable, such as clicking and placing multiple objects and customising the placement of various assets once they were added to the scene. These issues were due to the ZapparAR platform's limitations and the “easy to launch” Zappar Code process (Zappar, 2023a). This is a good route for a simple AR experience with a single object or scene. The software involves either a web interface or a simple graphical user interface which is PC/Mac compatible. Example projects are numerous and often include a step-by-step tutorial virtually anyone can follow (Zappar, 2023b).

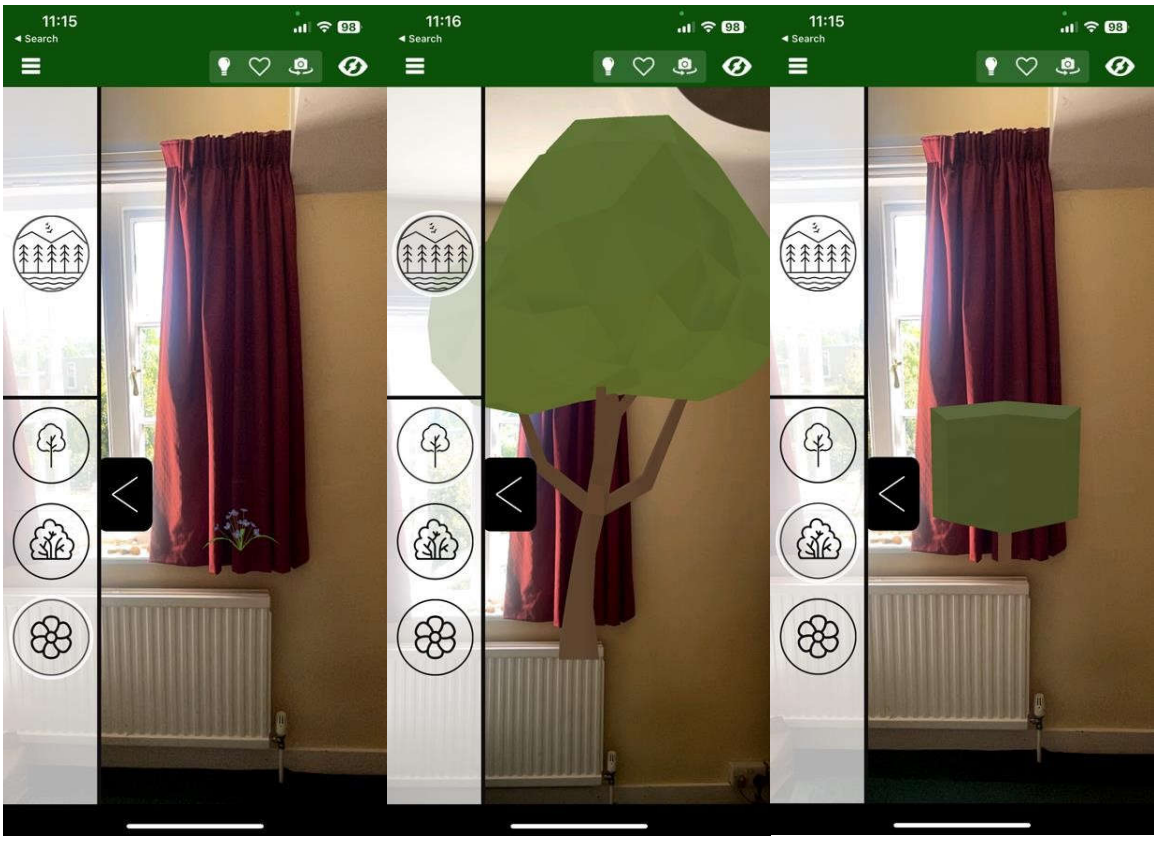

Figure 6: Screenshots of the proof-of-concept AR application in Zappar with a flower, tree and bush individually.

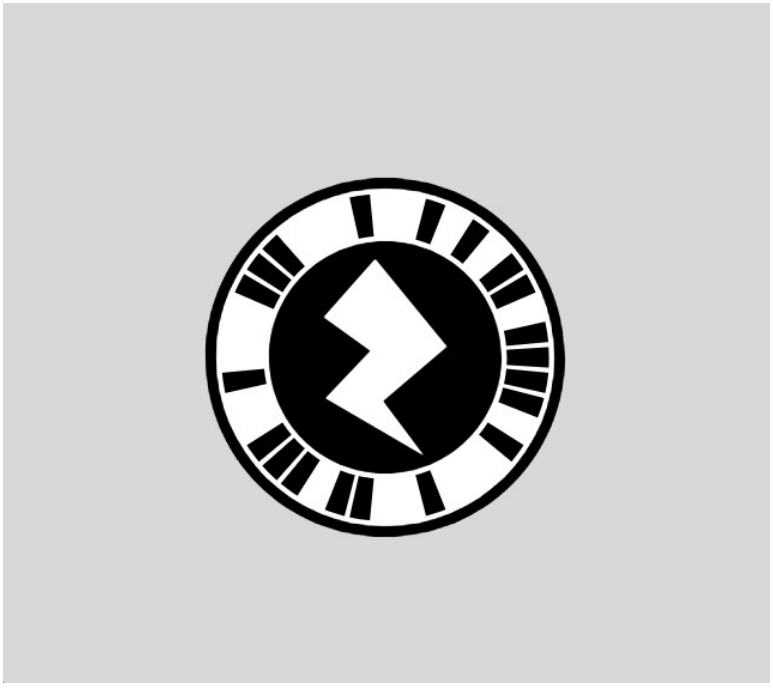

Figure 7: Zap Code of the proof-of-concept AR application in Zappar.

Discussion

Design Reflections

The project implemented a simpler version of the application in Zappar and a more complex version in Unity3D. While the Unity3D application is technically more robust, it cannot efficiently run on older smartphones, resulting in rendering issues and lag times even for low-fi 3D models (Google for Developers, 2023). In contrast, the more basic Zappar application allows users to “plant” a tree, flower, or bush and return to it periodically. The development of a “low-grade” version (available to all users) and a “high-grade” version (available to users with newer devices).

In both designs, the low-fi graphics mirror popular apps targeted at broad age groups and used colours that reflect what would be found outdoors across different seasons. Additionally, the concept aims to encourage one to get up and go outside given the best user experience is enabled when the app is used in an open outdoor space. The Zappar application is easy to customise, and new content can be loaded with the same filenames and instantly replace the older models, to include diverse species. The sustainability of both versions of the application is also fairly certain, as Zappar has a stable development environment that will likely continue for at least 3-4 more years, and Unity3D is constantly maintained, including support for legacy versions when new installs are released.

Technology Reflections

Once the development was complete, the design team interviewed the technical team members about their experience working on the project. According to the team, no significant issues were experienced in the development process. Any challenges resulted from smoothing the “user experience design” aspects of the project. The lead developer recommended that should AR development projects proceed, substantial time would be needed for researching and designing the application experience. Such an approach was recommended because it has been shown to often result in higher application adoption and return rates (Cho, Cheng, & Lai, 2009; Minichiello, Hood, & Harkness, 2018). Developers recommended researching the code base for existing popular AR applications as an existing application could likely be adapted and repurposed which can save time and resources.

A summary of the reflections of Unity and Zappar are outlined below:

Benefits of Unity

- High functionality: Unity offers extensive capabilities for developing complex AR applications, making it suitable for projects with advanced technical features.
- Versatility: Unity can be used for a wide range of applications, including complex mobile games, offering flexibility in design and development.

- Extensive documentation and resources: Although the lead developer mentioned some challenges, Unity benefits from a substantial amount of documentation and troubleshooting resources, making it easier for developers to find solutions.

Negatives of Unity

- Complexity: Unity is more complex and requires substantial time for researching and designing the application experience, potentially resulting in longer development timelines.
- Frequent updates: Application builds in Unity can quickly become outdated, necessitating ongoing maintenance and updates.
- Complex scripting: Editing user interaction triggers in Unity can be challenging, requiring complex alterations to the scripting language.

Benefits of Zappar

- Easy to use and simple to install: Zappar offers a user-friendly development approach, making it accessible for educators, outdoor engagement practitioners, and young people.
- Well-maintained: Zappar is well-maintained and easy to use, ensuring stability and reliability in application development.
- Customised AR experiences: Zappar allows for creating simple and customised AR experiences, making it suitable for teaching and outdoor engagement projects.

Negatives of Zappar

- Limited functionality: Zappar's feature capabilities are insufficient for developing advanced technical features, such as multi-object in placement and complex interactive features.
- Insufficient for replicating Unity: Zappar lacks the functionality to replicate the complexity of Unity applications, especially for projects leveraging cutting-edge graphics technology.
- Less versatility: Zappar may not be suitable for projects that require a high level of technical versatility, such as complex mobile games.

In summary, the choice between Unity and Zappar depends on the specific project requirements and design goals. Unity offers greater functionality and versatility but is more complex and requires ongoing maintenance. Zappar is user-friendly and well-suited for educational and engagement projects but has limited development capabilities. The decision should consider the desired features and design ethos of the project.

Nature Disconnection & Technology Opportunities

The 'extinction of experience,' as described by Pyle (1993), refers to the common disconnection of people from nature, which can be partly attributed to the prevalence of sedentary lifestyles (Soga & Gaston, 2016) and the development of technology and smartphones (Hughes et al., 2018; McCurdy et al., 2010; Wen et al., 2009). This extinction

of experience may lead to a situation where each successive generation imparts less knowledge and familiarity with the natural environment, resulting in what has been termed 'generational amnesia' (Kahn, 2002). Recent evidence suggests that the general public possesses significantly limited knowledge about common native species and lacks a profound comprehension of local biodiversity (Balmford, Clegg, Coulson, & Taylor, 2002; Lindemann-Matthies & Bose, 2008), aligning with the concept of shifting baseline syndrome (where past ecological conditions are forgotten as awareness of biodiversity evolves (Papworth et al., 2009). Consequently, generational amnesia can result in future environmentalists and policymakers undervaluing the importance of the natural world and experiencing shifting baselines (McClenachan et al., 2018).

The decline of nature experience in younger generations can be attributed to the fact that the most prevalent encounters with nature occur indoors through technological entertainment (Dorward et al., 2016; Hughes et al., 2018; Moss, 2012). A study carried out in southern England revealed that only 32% of the population spent time in natural environments (Cox et al., 2017). Additionally, previous research conducted by Wen et al. (2009) discovered that 37% of children spent less than thirty minutes engaged in outdoor activities after school, while 43% devoted more than two hours per day to television or computer screens.

Despite technology previously enabling low physical activity and disconnection from nature, the use of technology such as AR could be explored further to see if it can be used as a mechanism to enable nature engagement, access and recreation. Use of VR and AR have previously demonstrated increased emotional empathy (Martingano at al., 2021) between people and decreased psychological distance of products which may be transferable to a nature setting (Uhm et al., 2022).

The following outlines specific ways AR could be explored to address some of the nature disconnection challenges discussed:

- **Historical Overlays & Digital Storytelling**: AR can overlay historical images, videos, and data onto current outdoor environments. Users can witness how landscapes, ecosystems, and wildlife have changed over time, helping them recognise shifting baselines and reducing generational amnesia. This technology can show what was once considered "normal" and highlight the importance of preserving what remains.
- **Immersive Experiences**: AR creates immersive and interactive experiences that bring nature and environmental issues closer to the user. It can simulate natural environments, allowing individuals to virtually explore and experience the natural world as if they were there. This bridges the psychological gap and fosters a deeper connection to nature.
- **Data Visualisation**: AR can display real-time or historical environmental data in outdoor settings. Users can see visual representations of ecological trends, pollution levels, or climate data. This makes abstract environmental concerns more tangible and easier to understand.
- **Interactive Learning**: AR can be integrated into educational programs, such as outdoor education. It provides interactive and engaging lessons about the

environment, climate change, and conservation. Students can actively participate in learning about environmental issues through AR-enhanced activities (Francisco et al., 2023).

- **Virtual Scenarios**: AR can simulate various environmental scenarios, such as the impact of pollution or climate change on specific areas. Users can interact with these scenarios, enabling them to better grasp the potential consequences of certain actions and the importance of sustainable practices.

Overall, AR's ability to merge the digital and physical worlds makes it a valuable tool for connecting people with nature and making environmental concerns more accessible and relatable. It has the potential to inspire greater appreciation for the environment and motivate individuals to act in addressing environmental challenges.

Strategies & Recommendations

The learnings from the proof-of-concept build can be tailored to engage new and younger audiences with nature engagement experiences in urban and rural settings; whether that be to empower young children to design a rewilded urban area, engage audiences in nocturnal or hard to spot fauna, or encourage visitors to walk along nature trails within a nature reserve to limit recreational disturbance.

Nature engagement AR applications can play a pivotal role in engaging new audiences. Here are some strategies to achieve this and support nature engagement:

Interactive Learning & Encounters: Design AR experiences that offer educational value by providing information about the flora, fauna, ecosystems, landscape, or historic environment present in these settings. Users can learn about the environment, fostering a greater appreciation for nature and virtually engage with nocturnal or rare species as well as foster a holistic appreciation of the area.

Tip: Ensure the screen is not overcrowded with text

Gamification: Introduce gamified elements to make the experience fun and engaging. Incorporate challenges or scavenger hunts that encourage users to explore and learn about their physical surroundings.

Tip: Encourage use of all their senses to engage

Geo-tagging and Wayfinding: Use AR to provide users with navigation assistance in rural settings. Offer maps, trail markers, or location-based information to help users find their way and discover points of interest while also encouraging visitors to stick to paths in areas that may be under pressure (Kamarainen et al., 2018).

Tip: Application statistics may help to identify visitor hotspots

Storytelling: Craft immersive stories or narratives that take users on a journey through nature. This can help create an emotional connection and deeper engagement with the environment (Cummings et al., 2021).

User-Generated Content: Enable users to contribute to the app by sharing their own discoveries, photos, or observations. This builds a sense of community and encourages exploration and can encourage community participation and stewardship of these natural spaces.

Tip: Consider safeguarding when users can share data

Seasonal Changes: Highlight the dynamic nature of the environment by showing how it changes with the seasons. Users can witness the beauty of nature throughout the year.

Accessibility: Ensure that the AR app is accessible to people of all ages and abilities. Consider features like audio descriptions, text-to-speech, and compatibility with assistive technologies.

Tip: Ensure audio or accessibility option can be switched or off to cater to needs

Co-development: Co-designing and co-producing with desired audiences to fully achieve an engaging user experience and learning/ engagement goals will likely increase retention and long-term usage.

Feedback: Allow the local community to provide input and feedback on the AR app's content and features. This can help tailor the app to local needs and interests.

Tip: A feedback survey can be incorporated into the app without intruding on the experience

Engaging new audiences with nature in both rural and urban settings requires a thoughtful blend of technology, education, entertainment, and community involvement. By creating AR applications that align with these principles, you can encourage people to connect with and appreciate the natural world in their surroundings.

Questions to Consider

1. What are the precise learning goals the app would like to achieve?
2. What engagement opportunity will be enhanced with an AR application?
3. Who is the primary audience for the application?
4. Will the application be customised by non-specialist semi-regularly?
5. What existing technology is available to make this process relatively simple?

6. What learning outcomes can be delivered and impacted better through these modes of engagement?
7. Will the audience be able to use and engage with these modes effectively?
8. Will there be a legacy effect?
9. Will the application be a novelty or long lasting?

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Glossary

AR: augmented reality

Asset: digital files

Low/ High-Fidelity: the level of detail and functionality that a design has

Microsoft HoloLens: a device that enables someone to see and interact with holograms that are projected onto your environment, using gestures, voice commands, and eye tracking.

Mixed reality: a blend of the physical and digital worlds

Unity: Unity is a widespread and popular tool used by augmented reality developers.

VR: virtual reality

XR: extended reality

Zappar: a dedicated platform for AR development for mobile devises and web applications