

## Intergenerational Technology Codesign in Deprived Coastal Regions

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**Abstract**— Many coastal and rural areas in Britain are deprived. This regional aspect multiplies the effect of digital exclusion for older people. Younger people in these regions can also be digitally excluded. Codesigning digital technologies, using the natural and heritage resources of such regions would address this, but is rarely done. We present our methods and preliminary results, half-way through a 30-month project to develop novel technologies in extended reality, underwater telepresence, digital social games, and artificial intelligence voice interfaces and to use these assets to tackle digital exclusion. We are taking an intergenerational approach, working with 35 partner organizations, some to identify possible technologies and others to help with recruitment. Between August and December 2023, we ran 5 extended reality and 3 underwater telepresence intergenerational codesign workshops with a total of 36 attendees (24 older (50+ years old) and 12 younger (16-30 years old) participants). Social games and voice interaction workshops started in early 2024. In total we aim to recruit 120 participants (80 older, 40 younger) and codesign four new technologies. We present our experiences in recruitment and workshops. This has lessons for (i) other regions facing similar issues of digital accessibility, (ii) those codesigning novel technologies for older people, (iii) those working in extended reality, underwater telepresence, social games, and voice interfaces.

**Keywords**- digital inclusion; codesign; coastal regions: extended reality; underwater telepresence; social games; voice interfaces.

### I. INTRODUCTION

Older and younger people living in coastal and rural areas, such as Devon and Cornwall (D&C) in England, face significant health inequalities [1] [2]. Although most solutions often lie with politics and economics, the codesign of human-centered digital technologies that reduce inequalities and empowers an equitable digital society, is also imperative. Three types of digital equity exist: (i) digital connection – being able to access the same digital facilities and services as everyone else; (ii) digital employability – having an equal chance for jobs in the digital economy and (iii) digital enablement – using digital to have equal chance of participating in aspects of society otherwise denied.

The benefits of a digital society are not equally distributed across different demographic and socioeconomic backgrounds. For example, older people often do not use digital technologies at all, or only minimally due to inequity in digital connectivity and enablement [3]. Furthermore,

while older people’s links with community, resources and meaningful activities are essential in supporting health and well-being, these links are increasingly dependent on a digital connection, often meaning Digitally Excluded Older People (DEOP) are at risk of being engulfed by an additional sphere of exclusion. For Younger People (YP), digital employability equity is of greater concern with disparities in opportunities for digital employment and career aspirations.

In England, the most disadvantaged regions are often coastal, characterized by areas of low productivity and high deprivation. Traditional industries, such as farming, mining, fishing, and port activity, have all declined, with alternative, often high-wage digital sectors struggling to emerge, resulting in an exodus of younger skilled people. Those left behind, may be from poorer backgrounds, lacking secure and well-paid jobs, or a clear sense of career ambition. Disadvantaged regions need to use the assets they have to try to address these digital inequalities. In England, many coastal regions, including D&C, have social, environmental and heritage assets. While access to such cultural and environmental assets are known to improve health and wellbeing, equitable access is not always available to older people. And the converse is also true, that digital equity is important for the economy of ‘left behind’ coastal regions. Digital technologies are becoming essential in presenting and connecting with local culture. The cultural landscape together with community groups makes a cultural ecosystem that gives a region its unique identity, helping to promote its economy to the outside world [4].

Technology for intergenerational connectivity is an emerging field [5]. Lack of technical support is often the main contributor to digital exclusion among older people. YP often adopt new technology quickly so can act as ‘digital champions’ for DEOP. Positive benefits of intergenerational activities are also widely reported for YP, many related to educational and developmental gains and improved attitudes towards older people [6]. Work with companion robots demonstrated well how YP’s design ideas for technology may be different from older people’s expectations [7]. However, intergenerational co-creation may bring ideas that older people had not thought of but are acceptable and useful.

Research codesign is now widely used [8] and there is prior research on intergenerational digital codesign [9]. Our project learned considerably from the prior work on the Generating Older Active Lives Digitally (GOALD) project

funded by the Economic and Science Research Council [10]. GOALD tried to take an intergenerational approach to digital design but had problems in recruiting younger people [11]. Nevertheless, we learned from their experience in running codesign workshops and from the guidance for developers of digital products for older people that they produced [12].

The ICONIC project (Intergenerational Co-creation Of Novel technologies to reconnect digitally excluded people In Coastal communities) is a 30-month project. We are taking an intergenerational approach to address digital exclusion in older people and digital economic/employment exclusion of younger people. It is important to know if being intergenerational is a necessary component of co-creation. We need to know if and how this approach leads to differently designed more inclusive technology. We have chosen four technologies that may connect people to community and cultural landscape in our coastal region: extended reality, underwater telepresence, social games and AI voice interfaces.

Immersive experiences can help improve wellbeing for people unable to visit certain places due to mobility problems. This is a major issue for heritage sites, sites of special scientific interest, and coastal landscapes where there is often limited ability to modify construction. Climate change, flood and coastal erosion create additional risks and put increasing pressure on the need to facilitate novel and sustainable visitor experiences, and tourism [13]. *Extended reality* (XR) allows people to experience those spaces virtually and enjoy the wellbeing and psychological benefits. A better understanding of the importance of the marine environment enables us to take this a step further into *underwater telepresence*, celebrating the rich marine environment of D&C.

Connecting with others helps address social isolation and in that respect the importance of technologies, such as videocalls, has been demonstrated in care homes and for people unable to travel during the pandemic. But often more is required than just the opportunity to talk. *Digital social games* have been shown to be a key motivator in connecting, educating, and engaging people and more importantly keeping people engaged. They offer possibilities for the communication of specific values and information while simultaneously engaging previously disconnected audiences. Digital games also have the capacity to engage hard to reach audiences and minority groups but also allow for the valorization of heritage, often a strong motivation for rural regions and marginalized groups. While more generic history-themed digital games are commercially available, the potential health and wellbeing benefits of digital games based on the specific history and historic environment related to the cultural identity of D&C had not yet been explored and so is a focus of ICONIC.

Finally, while the three technologies above can be used to engage individuals with some level of digital awareness, skills and/or device ownership, we need ways to engage those most digitally excluded - those without internet access or digital devices. This group, for reasons of cost, awareness, lack of skills and/or support perhaps due to isolation may never use broadband or own a digital device but nevertheless

can be connected to the digital world through existing phone technology. *Voice interaction with the Internet* is now commonplace through smart speakers but making that available by telephone to an older Internet naïve population has had little research. Voice interaction by phone via chatbots to community and cultural resources could help reconnect DEOPs, particularly those with visual impairments.

The ICONIC project therefore aims to co-create appropriate and human-centered technologies focusing on extended reality, underwater telepresence, social games and voice Artificial Intelligence (AI). The project is trying to capitalize on existing cultural and environmental assets in D&C to address challenges faced by both DEOP and YP. ICONIC is necessarily an inter-disciplinary project with a team drawing on computing science (including AI, games, robotics, vision), public health, psychology, architecture, art and design, history and heritage, marine biology, and business studies.

The rest of the paper is structured as follows. In Section II we present ICONIC's research questions and in Section III, the objectives. As this paper focuses on methods, in Section IV, we present our methods in detail. The preliminary results and discussion are in Section V. Section VI concludes our article.

## II. RESEARCH QUESTIONS

The six main research questions for this 30-month project are: (i) Is intergenerational co-creation of the four identified technologies feasible? (ii) Does intergenerational co-creation promote an equitable digital society in coastal Britain? (iii) Which of the four technologies are more susceptible to intergenerational co-creation and what preferences do DEOP and YP have in using these technologies? (iv) Which approaches lead to a sense of connection with community and cultural landscape for DEOP and help develop confidence, communication skills, and employability for YP? (v) Does intergenerational co-creation lead to differently designed technology with more potential for inclusivity? (vi) What are the technical and social requirements to develop, adopt, scale-up, spread and sustain these technologies?

## III. OBJECTIVES

The objectives of ICONIC include: (i) To engage with local partners who will help with recruitment and who have various digital resources related to the social, environmental, and heritage assets of the region; (ii) To recruit 120 participants (80 DEOP, 40 YP) with the help of those external partners; (iii) To codesign four novel technologies by taking an intergenerational approach in a series of workshops; (iv) To document group working by external observation and internal reflection to assess the impact of intergenerational working between the four technologies on design; (v) To assess whether using the four co-created technologies improves digital access and wellbeing and sense of connection for DEOP or digital involvement or digital employability of YP; (vi) To explore sustainability

through opportunities of embedding these processes into curricula for further and higher education students.

#### IV. METHODS

##### A. Regional Partner Organisations

An initial stage (Objective (i)) was to meet with existing partners to explain ICONIC's aims and to explore their related resources and needs. By December 2023 we had met with and had the support of 35 organizations (Table 1). Some partners had both resources and experience of using digital to engage with the digitally excluded. For example, the Ocean Conservation Trust runs the 'Oceans For All' sessions, in which residents can view 360 degree videos recorded inside the tanks of the National Marine Aquarium (NMA) in Plymouth, and Geevor Tin Mine in Cornwall have developed a Virtual Reality (VR) tour to provide remote access to their 18th Century mine-workings heritage site. To support voice AI development, we are working with small and medium enterprises (SMEs) including PatientCards, who are providing access to their social prescribing network that can be accessed through the Help@Hand mobile application, which can provide a sample information available through the technology.

##### B. Recruitment of Participants

We have worked with our partners to recruit older people (aged 50 or over) and younger people (aged 16-30) (Objective (ii)). The project has ethical permission from the University of Plymouth Arts, Humanities and Business Research Ethics and Integrity Committee (09/05/23; project ID 3941). Our primary method of recruitment has involved recruitment partners (Table 1) sharing adverts of the project with potential participants. This strategy was supplemented through contacting additional groups (such as the University of the Third Age, a network that supports education for retirees) that are not partnered with the project directly, to attempt to recruit participants that are 'digitally excluded'. Further recruitment of YP was conducted through the University, to ensure an intergenerational component for the workshops. Although university students are not a good fit for 'digitally excluded' some, such as nursing students are not particularly digitally proficient and given problems of recruiting younger people we have compromised to ensure the intergenerational aspect of the project. Participants are reimbursed for their participation with vouchers, with additional vouchers available to cover costs of transport and time to travel to the workshop venue. Before the first workshop, we meet with participants either in-person or remotely (via phone or Zoom) and they are interviewed to gauge their current engagement with digital technologies, local heritage and the environment, and their local communities. By December 2023 we had recruited 47 DEOP and 22 YP. Outside of networks within the University of Plymouth, recruiting YP has proven more difficult than recruiting DEOP due to workshops conflicting with working or education hours. This is being addressed through

embedding workshops within work being conducted by community groups in Cornwall that work with YP.

As participants are being recruited from a diverse range of backgrounds, there is considerable variation in the nature of digital exclusion reported in their recruitment interviews. Participants have reported barriers to accessing technologies, including lack of skills, costs, and poor local infrastructure [14]. One commonality across most participants, however, is a keen interest to learn more about the technologies being codesigned as a part of the ICONIC project. Participants have shown the greatest interest in the Underwater Telepresence technology, with XR a 'close second', as both technologies can be used to make difficult to access spaces more accessible to a wider audience. Social games technology has registered the least interest from participants, with some older participants reporting negative attitudes to digital games.

##### C. Overview of the codesign workshops

Objective (iii) is to codesign four novel technologies by taking an intergenerational approach in a series of workshops. The iterative process of technology development we are using is like Participatory Inquiry approaches generating knowledge collaboratively and iteratively where research and action are linked through critical reflection [15]. Our approach is based on an extension of the Participatory Inquiry method called Research through Design [16]. Stakeholders are involved at all development stages of the project from initial problem-framing to the later development stages (for example, designing interactions). To accommodate the iterative nature of the codesign process, we have set up monthly time-boxed development windows and each technology will have between 7 to 10 workshops. From the technical point, this setup provides a suitable timeframe to plan, develop the technology, deliver the workshop, and analyze the results of the workshop to generate knowledge (Figure 1). One of the main benefits of the monthly workshops is repeated, consistent interaction with the participants: a key ingredient for building a productive collaborative relationship.

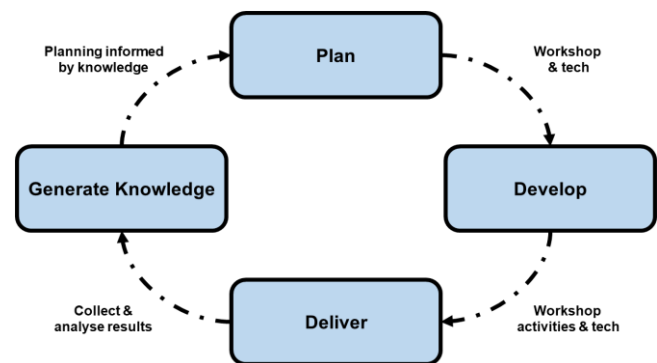


Figure 1. Monthly iterative process used to extract knowledge from the codesign process. The outcome of each process is being used to inform the planning and delivery of the next workshop.

TABLE 1. SUMMARY OF 35 PARTNER ORGANISATIONS SUPPORTING WORK ON THE ICONIC PROJECT SHOWING THEIR ROLE IN EITHER PARTICIPANT RECRUITMENT (PR) OR TECHNOLOGY CONTENT (TC).

Partner	Brief Description of Partner	Role
Abbeyfield	Charity providing housing, residential care and support to older people [17]	PR
Age UK Cornwall	Charity supporting older people (federated independent branches) [18]	PR
Age UK Plymouth	Charity supporting older people (federated independent branches) [19]	PR
Carnon Downs	Village community/hall in Carnon Downs, Cornwall [20]	PR
Centre of Pendeen	Village community/hall in Pendeen, Cornwall [21]	PR
City College Plymouth	Plymouth Further Education college, providing education for students aged 16+ [22]	PR
CN4C	Social enterprise supporting individuals in Cornwall with economic/social issues [23]	PR
Cornish Mines	World Heritage Site preserving 18 <sup>th</sup> and 19 <sup>th</sup> century mining sites in 10 locations [24]	TC
Cornish Mining NT	Heritage Site preserving Tin Coast mining region: 3 locations in west Cornwall [25]	TC
Cornwall AONB	National Park (Area of Outstanding Natural Beauty) covering approximately 27% of Cornwall and comprising twelve separate areas, eleven of which are coastal [26]	TC
Cornwall College	Cornwall Further Education college, providing education for students aged 16+ [27]	PR
Cornwall Digital Exclusion Network	Team embedded in Cornwall Council to support access to digital tools and services in Cornwall and the Isles of Scilly [28]	PR
Cornwall Museums Partnership	Charity that works collaboratively across museums in Cornwall to promote wider engagement with Cornish heritage [29]	TC
Cotehele National Trust	An estate with a medieval house that has been developed across the Tudor and Victorian eras additions located in the east of Cornwall run by National Trust [30]	TC
Dartmoor Nat. Park	Historic national park in south Devon with extensive Bronze Age heritage [31]	TC
Exmoor National Park	National Park located in Somerset and north Devon [32]	TC
Geevor Tin Mine	Historic 18 <sup>th</sup> century mine site in west Cornwall [33]	TC
Healthwatch Torbay	Non-profit organisation supporting health and social care in Torbay, Devon [34]	PR
PatientCards	SME running the Help@Hand social prescribing mobile application used as information sources by the ICONIC Voice AI technology [35]	TC
Hi9	SME specialised in voice AI interfaces [36]	TC
iSight Cornwall	Charity supporting individuals with sight impairments in Cornwall [37]	PR
Made Open	SME that runs Cornwall Link and Devon Connect directory websites used as information sources by the ICONIC Voice AI technology [38]	TC
Minack Theatre	Historic open-air theatre in west Cornwall, with views over Porthcurno Bay [39]	TC
Mount Edgcumbe	Historic Park and stately home in south-east Cornwall [40]	TC
Newquay Orchard	Community group in Newquay, Cornwall [41]	PR
Nudge	Community group in Plymouth [42]	PR
Ocean Conservation Trust	Charity focused on ocean conservation, that runs the National Marine Aquarium, Plymouth [43]	TC
Plymouth CH	Plymouth Community Homes (PCH) -Large housing association [44]	PR
Plymouth Digital Exclusion Network	Team embedded in Plymouth City Council to support access to digital tools and services in Plymouth [45]	PR
Plymouth Sound National Marine Park	The UK's first national marine park, based in Plymouth Sound [46]	TC
Saltram National Trust	Park and Georgian stately home near Plymouth run by National Trust [47]	TC
South Devon AONB	'Area of Outstanding National Beauty' National Park located in south Devon [48]	TC
South Devon College	Further Education college in Torbay, providing education for students aged 16+ [49]	PR
The Eden Project	Attraction in Cornwall comprising domes housing emulations of natural biomes [50]	TC
Torbay Community Development Trust	Charity supporting community development in Torbay, South Devon [51]	PR

#### D. Extended Reality (XR)

Our work with XR technologies aims to give older people with mobility impairments access to experiences in sites of cultural and historical significance, addressing the limitations of commercially available VR systems while creating bonds with specific places and communities. This builds upon previous work on the development of XR systems for digital heritage, which focused on Powderham Castle and the Higher Uppacott medieval site in Dartmoor National Park [52]. We are focusing on Cotehele (Table 1), a site managed by the National Trust which preserves a series of medieval buildings and historic garden in Cornwall. Despite the best efforts of its local team to improve accessibility and the visitor experience, the site includes buildings with some accessibility issues, such as narrow corridors and steep steps, and limited public transport.

Between August and December 2023, we ran five workshops with a total of 12 DEOP and 6 YP. We used a Quest 2 headset by Meta to give participants a VR immersive experience (Figure 2). Activities included multiple methods of documenting, experiencing, and speculating about historical sites and their potential to elicit wellbeing principles such as social cohesion and intergenerational interactions. These included 360 video demonstrations, persona-based experience design workshops, and activities to test ergonomics of XR hardware for older users. The latter resulted in the development of bespoke controlling and handling functionalities for the Quest 2 headset. We 3D scanned and documented artefacts for the Cotehele team as part of our partnership working. XR workshop activities will resume in June 2024 to address the integration of locomotion and interaction design elements, and to incorporate narrative and storytelling strategies on the final codesign of XR experiences.



Figure 2. Participant trying out a virtual reality environment via a head mounted display in one of the codesign workshops.

#### E. Underwater Telepresence

We want to give people the feeling of being underwater while onshore and to see an environment they have never seen before. Our initial codesign workshops revealed several barriers to engaging with the underwater world, such as

financial constraints, time commitments, physical fitness requirements, and discomfort due to cold water. While initially, we intended to deliver the experience via a remotely operated vehicle, through a scoping review [53] we identified other potential technological implementations of underwater telepresence characterized by the trade-offs between accessibility, interactivity, as well as the complexity of installation and maintenance. Between September 2023 and February 2024, in partnership with the NMA, we ran five workshops with a total 12 DEOP and 6 YP, where through focus groups, problem-framing, physical prototyping and educational technology demo sessions, a preference emerged towards an immersive, real-time experience of a local underwater environment with on-demand access to information about the surroundings. These preferences have been distilled into a prototype of a live video streaming from a static 360 camera with a backend marine life classification engine and a simple user interface delivered over the head-mounted display with interactive controllers.

#### F. Digital Social Games

Digital games are a key technology for engaging with user groups that are often hard to reach otherwise. Social games, adds a social component into the mix, which allows the formation or retention of communities. We aim to develop a new digital social game creation framework inspired by casual game creation apps [54] such as Wevva [55] that will provide co-creation groups with the technology for understanding, exploring, and creating games while not having access to more expensive computing hardware. In discussion with project partners NMA “Blue Meadow team” we decided to focus development on the topic of seagrass and its growing process. The beneficial role of seagrass as part of the local ecosystem and its ability to combat the effects of climate change identifies with the ethos and beliefs of the local coastal community. Thus, making it an ideal candidate theme for a social game. The topic also provides links to another technology in the project our work with underwater telepresence and builds on local strengths. The codesign process for social games will take place over seven workshops starting in the first quarter of 2024 covering every stage of development (Figure 1). We start with the problem-framing process and introduction to game design aspects followed by the introduction of social features and culminating in an application that follows the steps of seagrass cultivation. The lessons, tools and approaches used during game development will become the foundation of an open-source framework that will enable the development of similar games for social enterprises.

#### G. Voice AI (Phone-based Access to Internet Services)

Nearly 40% of those 75+ in the UK had never used the internet in 2020 [56]. Providing them with phone access to the Internet is one way to address such digital inequality. But even among those with internet access, previous research has shown that older people may abandon voice assistant services on smart speakers after unsuccessful attempts [57].

We will work with older and younger participants to discover how older people with no previous computer experience would want to interact with various resources. The main objective is to create bidirectional voice communication with internet services through phone calls, which can be achieved through an IP phone (IP PBX) server that is called by the DEOPs so that it connects them to the application programming interfaces (APIs) of the cloud-based voice assistants (e.g., Amazon Alexa) and services (Caller Smart Speaker API. These intelligent assistants receive voice-based instructions or questions from DEOPs and reply to them through the phone using the available information online or through the other connected service APIs.

This is being explored in the context of ‘social prescribing’ [58], which is an approach to connect people to community activities, groups, and services for their health and wellbeing in primary care. We have discussed with our content-provider partners trialing voice access to: (i) Cornwall Museum audio archives, (ii) the Help@Hand app by Patientcards for community group information, and (iii) Cornwall Link by AgeUK Cornwall, a website by Made Open. Our initial focus is the Help@Hand application, which has diverse activities, events, and services. We are conducting six codesign workshops starting January 2024, involving older and younger participants to design user-friendly voice interfaces. These workshops will employ common conversational interaction design tools like Wizard-Of-Oz (WoZ) for prototyping [59] Our pilot workshop revealed a need to explore subtle voice interaction features like pauses and intonations for natural voice interaction. We have partnered with Exeter University’s conversational analysis group to study these features to enhance user satisfaction and engagement in the provided service.

#### *H. Exit Interview, Evaluation and Analysis*

Participants will be interviewed on leaving the study to gauge their assessment of the intergenerational interactions within the workshops. We will also use workshop recordings to identify patterns in how the generations work together or if there are specific technical preferences associated with either age group. Some preliminary observations from workshops for the first two technologies suggest that DEOP tend to take the role of ‘directors’ and let the YP do the hands-on design activities/idea presentation. We will adapt and adjust our methods to try to get the best from this aspect of the study design. The participant ‘exit interview’ will be used to assess whether using the four co-created technologies improved their digital access, wellbeing and sense of community and environmental connection (for DEOP), or digital involvement and digital employability (for YP) (Objective (v)). Finally, we will be discussing with the further and higher education providers among our partners how to sustain opportunities and embed these processes into curricula for their students (Objective (vi)).

## V. PRELIMINARY RESULTS AND DISCUSSION

We are making progress in our aim to develop four novel technologies codesigned by intergenerational groups of people who are in some way digitally excluded living in coastal communities.

We managed to engage 35 partner organizations and by December 2023 had recruited 69 of our target 120 participants for workshops. Recruitment is difficult due to the requirement of older participants to be digitally excluded, and the availability of YP, meaning we have not yet reached the same intergenerational participant balance as other projects [60]. Attracting DEOP has required a focused effort to work with the project’s partners to share the project’s messaging. This has proven a successful approach, as it has allowed us to set up workshops in digitally marginalized areas, in which participants have articulated clear issues with the local digital infrastructure. A further barrier has been a lack of interest in the project from some groups due to the desire for more foundational access to technology, that can offer practical support for using digital technologies. It is difficult to recruit YP for synchronous events as they may be working or studying during daytime when DEOP want to meet, but our work to date has shown the importance of intergenerational collaboration [61]. Our approach in offering participants direct reimbursement appears to be more successful than methods used in GOALD [10][11]. We are pursuing various approaches to solve these problems including embedding the workshops in local community groups that work with YP and exploring the use of more distributed/asynchronous codesign methods that have been employed in response to the COVID-19 pandemic [62].

A further lesson from the codesign sessions is the importance, when working with digitally excluded older adults, to articulate the researchers’ impartiality, and emphasize the need to learn about the difficulties. Part of this messaging involves articulating that the project is not designed to push technology, but to identify how technology can support societal inclusion and support vulnerable populations, but also identify current barriers to vulnerable populations that prevent their access to digital resources.

Finding a niche for new technology development is also difficult given the rapidity of background technology developments. This is an unusual project in that we work very hard to engage the digitally excluded and with them to identify novel technologies while novel technologies are most frequently designed by those deeply embedded in and at the cutting edge of technology development. We are trying to be in ‘two places at once’ – looking at the digital accessibility needs of those who are infrequent users of technology, trying to make sure that their voice is heard by the technology developers.

Our project’s impact may be limited by the short timescale of digital developments. We may also be limited by the findings from this one geographical locality. It may therefore be difficult to find generalizable design recommendations, but we hope that at least the observations on our methods will be generalizable to other locations. It is quite a difficult ‘space’ to occupy but we think it is worth it.



## ACKNOWLEDGMENTS

This paper is presented on behalf of the ICONIC project that includes Katharine Willis, Daniel Maudlin, Chunxu Li, Sheena Asthana, Kerry Howell, Shangming Zhou, Emmanuel Ifeakor, and Hannah Bradwell as co-applicants and advisors and Lauren Tenn (Media and Administration Officer). We thank our 35 external partners (Table 1) and participants.

Intergenerational co-creation of novel technologies to reconnect digitally excluded people with community & cultural landscapes in coastal economies (ICONIC) is funded by UK Research and Innovation Engineering and Physical Sciences Research Council Grant Ref: EP/W024357/1.

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