Assessing pedagogic benefits of the virtual world to enhance fieldwork.

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Foreword

Abstract

This research explores the evolving landscape of fieldwork practice, particularly the integration of digital tools in Higher Education (HE) fieldwork within the biosciences.

Informed by expert panel interviews, a facilitators of fieldwork survey and student focus groups, the study examines the purpose of both traditional in-field approaches and emerging digital fieldwork practice. A fieldwork taxonomy is presented within this research, which uses pedagogic approach and delivery mode to define fieldwork practice.

It investigates the role students can play in co-designing digital tools to address specific pedagogical challenges in fieldwork. Using an iterative design process, the research develops a Digital Field Notebook (DFN), Digital preparation resources, and a Virtual Field Trip (VFT). Student feedback is also used to exemplify the Technology Pedagogic and Content Knowledge (TPACK) framework to support the integration of technology in fieldwork. Additionally, expanding upon the role of student partnership, this research examines the feasibility of working with students to design, develop and deliver low-cost live fieldwork broadcasts. In evaluating the co-production partnership valuable insights into skill development and the future role of live broadcasting in fieldwork are shared. Despite students being involved in developing the DFN and recognising the benefits of this digital tool, barriers to the digital tools, barriers to their adoption within biosciences fieldwork remain.

Recognising the need for practitioner training to address knowledge and skills gaps when adopting digital tools and the potential for adopting open scholarship practice, the digital tools were shared with the wider fieldwork community as Open Education Resources (OERs) during participatory workshops. These workshops played a key role in disseminating the tools, increases knowledge of the digital tools with participants, facilitating collaboration among attendees, fostering new ideas and supporting the integration of digital tools in fieldwork practice.

Acknowledgements

"You think you know what's to come, what you are. You haven't even begun." T. Maclay

"I'm cookie dough. I'm not done baking. I'm not finished becoming whoever the hell it is I'm gonna turn out to be. I make it through this, and the next thing, and the next thing, I turn around and realise I'm ready." B. Summers

I dedicate this work to all the students I've had the privilege of collaborating with throughout my research. From those who partnered with me closely to those who trialed resources, provided feedback, and completed surveys, it has been an honour to learn from and listen to you. My hope is that this work continues to support other students and helps build a more inclusive fieldwork environment that addresses the needs of those often underserved.

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Publications, open education resources and conferences

PhD publications

Maddison, J., Bevan, R.M. and Marsham, S. (2023a) 'Developing a digital field notebook for bioscience students in Higher Education', *Frontiers in Education,* 8, 1271789 pp. 1-16. doi:10.3389/feduc.2023.1271789. (Chapter 3).

Maddison, J., Bevan, R.M. and Marsham, S. (2025) 'Valuing student voice in the development of digital preparation resources for fieldwork'. *Journal of Adventure Education and Outdoor Learning,* pp. 1–22. doi: 10.1080/14729679.2024.2447745. (Chapter 3).

Maddison, J., Constantinou, L.A, Fletcher, E., Turner, C., Bevan, R.M. and Marsham, S. (2025) 'Co-producing a live fieldwork broadcast in the biosciences'. *Frontiers in Education,* 9*,* 1463338 pp. 1-17. doi:10.3389/feduc.2024.1463338 (Chapter 4).

Maddison, J., Sugden, H. and Marsham, S. (In-prep) 'A post-Covid taxonomy of fieldwork'. *GEO-Geography and Environment*, GEO Theme- The future of fieldwork in a changing world. (Chapter 2).

Maddison, J., Sugden, H. and Marsham, S. (In-prep) 'Participatory workshops: A method to assess participants' interest in adopting four digital tools in fieldwork education'. *GEO-Geography and Environment*, GEO Theme- The future of fieldwork in a changing world. (Chapter 6).

Other related publications

Kitchen, R. and Maddison, J. (2021) 'A fieldwork toolkit for early career geography teachers', *Teaching Geography*, 46(1), pp. 17-20.

Maddison, J. and Landy, R. (2024) Creative Fieldwork 2, Field Studies Publications.

Maddison, J., Foster, C., Morgan, D., and Marsham, S. (2023b) 'Developing a virtual sense of place', in Rawlings-Smith, E., and Pike, S. (ed.) *Encountering Ideas of Place in Education: Scholarship and Practice in Place-based Learning*. London: Routledge, pp. 168-180.

Maddison, J. and Thurston, S. (2022) 'Supporting the mental health and wellbeing of learners during residential fieldwork', *Teaching Geography*, 57(3) pp. 106-109.

Stagg. B.C., Dillon, J. and Maddison, J. (2022) 'Expanding the field: using digital to diversify learning in outdoor science', *Disciplinary and Interdisciplinary Science Education Research*, 4(9). doi:10.1186/s43031-022-00047-0

Conferences

Collins, T., Davies, S. and Maddison, J. (2024) '*Using interactive live broadcasts for developing students' practical skills'.* EDEN Digital Learning Europe NAP Webinar, 24th April 2024, online.

Maddison, J. (2024) '*Live from our fieldwork correspondent'*. Geographical Association Annual Conference, 5th April 2024, University of Manchester, Manchester.

Maddison, J. (2023) '*#NclLive- A student co-production partnership*'. Enhancing Field Showcase, 29th June 2023, University of Swansea, Swansea; 14th September 2023, University of Birmingham, Birmingham.

Maddison, J. and Thurston, S. (2023) '*Keynote: Reflections, practice, future and change'.* Wellbeing in Outdoor Environmental Education Conference, 22nd February 2023, University of Exeter, Exeter.

Maddison, J. (2022) '*Empowering student voice to co-design digitally enhanced inclusive fieldwork approaches'.* Enhancing Fieldwork Showcase, 14th September 2022, Open University, Milton Keynes.

Maddison, J. (2022) '*Student voice and virtual fieldwork: What do students value and want from a digitally enhanced fieldwork experience?'* Three Rivers, 29th June 2022, online.

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Background to the research

Personal motivations for the research

Having worked in the fieldwork education sector since 2010 facilitating fieldwork for students across a range of ages, I have witnessed firsthand the transformative impact that outdoor education can have on young people. During this time, I have also worked to train many practitioners and colleagues in delivering fieldwork to diverse learners. In this training role I have advocated to dispel the assumption within the sector, that fieldwork is beneficial for all learners, all the time. In my opinion, this assumption can perpetuate equality, diversity, and inclusion (EDI) barriers in fieldwork. It can also result in the blame being placed on learners themselves, if they do not have a positive fieldwork experience, rather than acknowledging or addressing the systemic barriers they may face.

In my professional experience, there are learners who are currently underserved within fieldwork, and as such do not fully benefit both educationally or personally from the experience. During the Covid-19 pandemic and the first UK lockdown from March to July 2020, fieldwork was stopped, and access to outdoor spaces restricted. Like many in the fieldwork sector, I worked to swiftly transition fieldwork to digital formats and delivery modes. While these digital fieldwork approaches could not fully replicate the outdoor experience, they provided an imperfect alternative that was necessary at this time. This period (March to July 2020) highlighted to me the potential for digital tools and digital delivery mechanisms to enhance existing fieldwork practice, better serve the needs of all learners and extend the reach of fieldwork education.

These formative experiences, coupled with my work in educational development during the Covid-19 pandemic inspire my current research, where I aim to explore the potential of collaborating with students to develop digital tools that address the challenges learners face in fieldwork, enrich their experiences, and foster a culture of belonging within the field.

Research positionality

I have always felt at ease in the outdoors, enjoying many positive fieldwork experiences and taking pleasure in facilitating fieldwork for others for over a decade. Despite being an active participant and advocate for EDI within the sector, I recognise that my perspective is shaped by my identity as a white, working-class, cisgender woman without disabilities. This inevitably limits my understanding of the challenges that others may face during fieldwork.

To address this and to broaden my perspective and enhance my own practice, I have actively sought opportunities to deepen my understanding of the experience of others during fieldwork. This underpins the aims of this research and is reflected in my research design where I have worked in partnership with students and engaged with other interested and affected parties during the exploration phase to uncover experiences of in-field fieldwork and digital fieldwork. Additionally, the insights gained from recent research projects and trainings such as Inclusivity in the Outdoors, Equator 2.0, and Cultivate have been pivotal in expanding my views. Like many in the field, I am continually working to increase my knowledge and experience in supporting those learners who are currently underserved in fieldwork environments.

Choice of language within this research

Although acronyms are defined within this research, certain terms used throughout the chapters may be interpreted differently by various readers. Table 0.1 offers definitions to ensure consistency of understanding of these terms within the context of this research.

Table 0.1 Definitions of key terms used throughout this research.

Term	Definition within this research
Fieldwork.	Teaching and learning activities that incorporate observing, collecting, and analysing information about the natural or built environment. With the aim of understanding the natural or built environment, developing subject-specific and/or transferable skills.
In-field fieldwork.	Fieldwork teaching and learning activities that occur outdoors in the natural or built environment.
Digital fieldwork.	The use of digital tools and approaches to deliver fieldwork teaching and learning activities.
Blended fieldwork.	The combination of in-field and digital fieldwork components that are integrated to present a learning pathway for fieldwork.
Hybrid fieldwork.	The combination of in-field and digital fieldwork components that happen at the same time. For example, some students may be collecting data in the field, while other students are analysing that data in real-time and comparing to secondary data available.
Virtual Field Trip.	A digital representation of a fieldwork environment.
Student.	Specific learners who are engaged within the research process presented in this thesis.
Learner(s).	A person(s) who is in the process of gaining knowledge and/or developing skills through fieldwork but is not directly involved with this current research process.
Practitioner(s).	Specific facilitator(s) who are engaged within this research process.
Facilitator(s).	The staff member(s) that are involved in supporting the teaching and learning during fieldwork but are not directly involved with this current research process.
Open Education Resources.	Free and publicly available teaching and learning resources.
Digital tools.	Software, hardware, websites, and applications (apps) that facilitate and enhance teaching and learning.

Pedagogy, pedagogic approach.	Methods of practice that are used to teach and through which learning occurs.
Digital delivery mode, digital approach.	Delivery of and learning from material delivered via digital channels or using digital tools and technologies.
This research, researcher.	Refers to the work within this PhD thesis, by this postgraduate researcher.

Participant codes

Participant codes are used throughout to attribute quotes, Table 0.2 provides the detail on the segmentation of codes across the different data collection methods used in this research.

Table 0.2 Participant codes used throughout the thesis to attribute quotes to different individuals from different data collection methods.

Data collection method	Number of participants	Participant code
Expert panel interview.	10	Exp A-Exp J
Facilitators of fieldwork survey.	57	F1-F57
Exploration stage student focus group.	22	S1-S22
Digital Field Notebook design.	7	S23-S29
Digital preparation design.	6	S30-S35
Virtual Field Trip design.	6	S36-S41
DFN impact.	107	S42-S148
Live broadcast.	5	S150-S154
Participatory workshop (student).	21	S155-S175
Participatory workshop (facilitators).	48	F58-F105
Digital Action Plan (DAP).	25	DAP1-DAP25

Chapter 1. Reviewing the landscape of fieldwork and the models which support the development and integration of digital tools in fieldwork

1.1 Reviewing the landscape of fieldwork

1.1.1 State of fieldwork

It is widely accepted that fieldwork plays an important role in biosciences teaching, with knowledge, affect, behaviour and skill-based outcomes for learners participating in fieldwork (Maw *et al*., 2011; Scott *et al*., 2012; Mauchline *et al*., 2013; Shinbrot *et al*., 2022). The Quality Assurance Agency (QAA) Subject Standard for biosciences does not specify the number or type of fieldwork activities required, it does however establish practical fieldwork skills as a graduate threshold standard (QAA, 2019; 2023). Notably, the 2023 QAA statement, unlike its 2019 version, includes a reference to virtual fieldwork opportunities, reflecting the increasing importance of digital fieldwork practice post-Covid-19 and the ongoing rethinking of field trips by many institutions (Geange *et al*., 2021; Nicotra *et al*., 2022; QAA, 2019; 2023; Oktavianto *et al*., 2023).

There was an optimistic outlook identified from a review of biosciences fieldwork provision across 30 Higher Education (HE) institutions (Mauchline *et al*., 2013) with the total amount of fieldwork remaining stable or increasing over the preceding five years. However, this review is now over a decade old and pre-dates recent fieldwork changes due to the Covid-19 pandemic. Although the comprehensive study provided valuable insights into the logistics of fieldwork provision, the quality of the fieldwork, a review of the pedagogic approaches and considerations of equity of access were not evaluated within the research. There is a need for more in-depth qualitative research to better understand the current state of biosciences fieldwork in HE.

Beyond the quantity and quality of fieldwork, it is essential to consider trends in fieldwork pedagogy. Communications and Information Technology (C&IT) were identified as an emerging trend in fieldwork within geography, earth, and environmental science (GEES) disciplines in 2002 (Fletcher *et al*., 2002). The adoption of C&IT in fieldwork includes fieldwork web-based resources, using mobile geographical information systems (GIS) during fieldwork and enhancing interactivity of fieldwork using virtual and multimedia tools. It is not clear within the literature whether these emerging trends have become standard practice in fieldwork beyond GEES disciplines or are there other trends representing new emerging digital tools.

Mobile devices can be used during biosciences fieldwork to collect, present, analyse spatial and temporal datasets and crowd-source fieldwork data (Stoyanova-Petrova, 2011; Huffling *et al*., 2014; Medzini *et al*., 2015; Verdes *et al*., 2021). However, the majority of these are shared with the academic community via individual case studies (France *et al*., 2015), and do not represent an embedded practice of using mobile devices in fieldwork.

Barton's 2020 Sankey mapping of fieldwork activities effectively summarises the fieldwork substitutions made in response to the Covid-19 pandemic. While useful in showing the adaptations made during a switch to remote teaching options, it does not explore the potential of integrating digital tools beyond the pivot during Covid-19 pandemic. These activities are also subjectively ranked from most learner-centred to most-instructor centred. This ranking provides only a limited review of the pedagogy of the remote fieldwork teaching. Within the literature on fieldwork practice there is no comprehensive taxonomy that defines both digital and in-field fieldwork activities using different pedagogic approaches. This research aims to address this gap by conducting a review of existing practices and developing a broad, non-subject-specific taxonomy of fieldwork activities.

1.1.2 A move to a more balanced view of fieldwork

Positive experiences of fieldwork and outdoor learning are widely documented across all age groups (English Outdoor Council, 2015; Streule and Craig, 2016; Peacock and Bacon, 2018; Beltran *et al*., 2020; van de Wetering *et al*., 2022). During fieldwork, learners often enter a state of liminality, where usual social structures and routines are temporarily suspended (Morales *et al*., 2020). This creates opportunities for transformative experiences, leading to positive outcomes such as increased confidence, resilience, and motivation (English Outdoor Council, 2015; Streule and Craig, 2016; Peacock and Bacon, 2018; Beltran *et al*., 2020; van de Wetering *et al*., 2022).

In addition to enhancing subject knowledge (Scott *et al*., 2012, Shinbrot *et al*., 2022) fieldwork offers learners valuable opportunities to develop a range of skills, which can be categorised into technical, transferable, and personal development skills. Fieldwork provides an authentic learning environment (Ordon *et al*., 2020) where learners can hone these skills in real-world settings. The development of such skills is a crucial component of degree programmes (QAA, 2023) and is highly valued by employers. A particularly important skill in the ecology sector is species identification, which, despite its significance, is often underdeveloped in graduates (Palmberg *et al*., 2019). Fieldwork participation is often compared to professional working environments, with learners forming collaborative working communities (Streule and Craig, 2016) during group activities. In these settings, learners engage in a team-based learning model that emphasises collaboration over competition (Beltran *et al*., 2020).

In a landscape of educational inequality (Clegg *et al*., 2017) fieldwork can be viewed as an equitable teaching and learning tool (Lavie Alon and Tal, 2015). However, with learner monetary contributions to HE fieldwork remaining the norm across UK institutions (Mauchline *et al.*, 2013), perhaps the barrier of inequality lies not in fieldwork outcomes but in the ability to participate in fieldwork.

While the overwhelming narrative both from anecdotal experiences and more recent literature seeking to support fieldwork within HE is positive, the benefits of fieldwork are not universal nor without exception, with barriers to participation and challenges present within the fieldwork experience itself (Hughes, 2022; Tucker *et al*., 2022). While the author's view remains incredibly positive of the role of fieldwork in HE, it is important to identify, consider and tackle the barriers and challenges present to ensure participation and success for all learners. Although the barriers to participation were not explored in Beltran *et al.*'s (2020) extensive longitudinal study of field courses in the United States, a diversity gap was identified between those participating and not participating in fieldwork. Mean field course attendance was -6% for under-represented minority students, -9% for students from low socio-economic backgrounds and -12% for first-generation students. Some research has attempted to reach learners who do not participate in fieldwork (Peasland *et al*. 2021), finding that high cost, low utility and low intrinsic value impacts participation meaning learners cannot prioritise attending fieldwork over other commitments.

Barriers to fieldwork can be classified into nine main themes; Risk, Learner Behaviour, Cost, Social Inclusion, Red- Tape or School Organisational Practices, School Culture, Teachers themselves, Utility, and Location (Cook *et al.*, 2006; Scott *et al.*, 2015; Peasland *et al.*, 2021). Within these studies barriers were identified by learners, fieldwork facilitators, school leaders and by those facilitating the fieldwork. Zavaleta *et al.* (2020) noted that for field courses to promote inclusion, steps need to be taken to recognise and remove barriers. This is an ethos promoted within the design of this research, as it seeks to capture challenges experienced within fieldwork and design digital fieldwork approaches to address these challenges.

Fieldwork is often seen by HE biology lecturers as an uninterrupted, intense, and efficient way to achieve learning objectives (Smith, 2004). While its transformative and immersive nature can be powerful, it also presents challenges. Learners are often placed in socially intensive environments (Dunphy and Spellman, 2009; Streule and Craig, 2016), required to adopt new roles (Glackin, 2018), work long hours, share accommodation, and participate in activities in remote and unpredictable settings (Tucker and Horton, 2019). This experience, though valued by facilitators of fieldwork, can be stressful and ineffective for some learners. Additionally, the idealised norms of strength and fearlessness associated with outdoor activities (Straker, 2018) can reinforce hegemonic masculinity (Oakley *et al*., 2018) further alienating some from participating in fieldwork (Tucker *et al*., 2022).

Learners with disabilities or additional and/or specific learning needs often face significant barriers to accessing and benefiting from fieldwork. Inclusive practices are particularly challenging when disabilities or learning needs are hidden, unidentified, or undisclosed (Taylor and Johnson, 2020). While there are recommendations for providing *'equivalent as possible'* fieldwork experiences (Houghton *et al*., 2020) and for designing more inclusive fieldwork (Atchison *et al*., 2019; Houghton *et al*., 2020), these are typically based on small case studies and are not universally implemented. However, these practices offer valuable insights that can help institutions meet accessibility requirements outlined in the QAA biosciences benchmark statement (QAA, 2023). This research seeks to promote a pro-active approach where the development and integration of digital tools within fieldwork, can support the broadest range of learners.

The location of fieldwork often presents a significant financial barrier to learners (Mauchline *et al*., 2013). While alternatives within the literature such as campus-based field teaching are successful in providing accessible ecology fieldwork (Peacock *et al*., 2018), learner enjoyment and outcomes can decrease when fieldwork is confined to familiar, local sites (Burke Da Silva, 2014). Fieldwork locations are often chosen not only for educational value but also to attract and retain students in HE courses (Peacock and Bacon, 2018). These capstone international trips to exotic locations serve a pedagogic function and as a marketing tool. However, the appeal of such locations must be carefully weighed against the inherent access, inclusivity, and sustainability issues they present (Gonzalez, 2024). This research will seek to explore a novel method of providing access to fieldwork locations, which could be applied to international fieldwork contexts, enabling access without the associated financial burden placed on learners.

1.1.3 The role of digital tools in fieldwork

There are a number of digital tools and approaches for both biosciences and GEES disciplines. Mobile devices are identified as a key digital tool in fieldwork education. Their widespread availability among young people, combined with features like real-time data collection and geo-location, supports efficient data collection and spatial data analysis (Welsh *et al*., 2012; Bettinson and Bird, 2021; Maddison *et al*., 2023a). Virtual field trips (VFTs) can provide immersive experiences of real-world field locations via guided observations, enhanced temporal views of fieldwork locations and access to otherwise unreachable sites (Klemm and Tuthill, 2003; Lee, 2009; Friess *et al*., 2016; Šašinka *et al*., 2019; Mead *et al*., 2019; Cowles and Onthank, 2021; Jeffery *et al*., 2021; Rodríguez *et al*., 2022; Hutchinson *et al*., 2024; Hagge, 2024). Some VFTs are enhanced through gamification principles and use platforms like Minecraft to re-create a simplified fieldwork landscape and increase learner engagement with the fieldwork environment through interactive elements (Rader *et al*., 2021). By incorporating Augmented Reality (AR) with gamification, learners can develop a stronger connection to fieldwork locations by visualising historical spatial data, and view 3D representations of organisms that may be challenging without the use of AR (Oleksy and Wnuk, 2017; Gazcón *et al*., 2018; Verdes *et al*., 2021).

Many of these digital tools and approaches for fieldwork have been designed by facilitators with learners reviewing the end digital fieldwork products (Xie *et al*., 2021; Wright *et al*., 2023; Arrasyid *et al*., 2024). There is minimal learner voice in the development of these digital tools, with learners also often omitted from research into the barriers of fieldwork (Cook *et al*., 2006; Scott *et al*., 2015). Adopting the principles of a 'Students as Partners' (SaP) approach (Healey *et al*., 2014) this research seeks to work with students to develop digital fieldwork approaches by identifying their priorities for digital fieldwork and uncovering their experiences of fieldwork.

Using live-streaming technologies means that real-time broadcasting of fieldwork to remote audiences can make fieldwork more accessible, especially when physical access to the field is limited (Stagg *et al.*, 2022; Brown *et al*., 2023; Open University, 2023). Although live broadcasting has been used as a delivery mechanism in medical education (Wang *et al*., 2021b; Williams *et al*., 2011; Brandt, 2020; Fang *et al*., 2022; Iwaki *et al*., 2013), its adoption in fieldwork is limited perhaps due to the need for outdoor specific, specialised technology and digital skills (Brown *et al*., 2023). Audience engagement has been identified as a challenge within live fieldwork broadcasts (Stagg *et al*., 2022). This current research aims to contribute to the small body of research on live fieldwork broadcasting by exploring its application beyond institutions with remote learner populations and considering how working with students in a co-production partnership can engage students with live fieldwork broadcasting. It will also investigate the feasibility of a low-cost, low-tech solution which has the potential to increase the uptake of live broadcasting in other institutions.

Virtual fieldwork has been identified as a significant factor in the decline of traditional fieldwork (Maw *et al*., 2011), as it can eliminate the need to leave the classroom (Boyle *et al*., 2007). However, some view virtual fieldwork as a valuable complement to traditional fieldwork approaches (Stokes *et al*., 2012), providing an additional link between classroom learning and the in-field experiences (Thorndycraft *et al*., 2009; Edwards and Larson, 2020). All of these perspectives were shared prior to the Covid-19 pandemic, with this period during the Covid-19 pandemic accelerating the shift towards digital fieldwork modes (Creech and Shriner, 2020). As we transition to a post-pandemic period, facilitators are now blending digital and in-field approaches (Creech and Shriner, 2020; McKinnon, 2020; Cowles and Onthank, 2021; Verdes *et al*., 2021), and this research seeks to capitalise on this momentum and integrate diverse delivery methods, potentially establishing a new norm in fieldwork practice that draws upon diverse delivery modes and a range of pedagogic approaches.

The literature suggests that technology can play a crucial role in addressing the needs of diverse learners. This integration of digital and in-field fieldwork components via a blended learning approach includes enhanced preparation before fieldwork and better integration between classroom and field experiences (Lang and Persico, 2019; Kingsbury *et al*., 2020). Pedagogic considerations and the inclusion of learners must drive digital interventions to avoid increased anxiety from learners (Kwet and Prinsloo, 2020), with careful scaffolding and empowerment via co-design processes (Lawrence and Dowey, 2022), which will hopefully minimise any anxiety among learners using the new digital tools.

Virtual fieldwork presents an opportunity to address access issues of traditional in-field fieldwork methods (Cooke *et al*., 2020). However, new challenges arise for learners when accessing resources in blended or fully digital environments. Preparing learners to engage effectively with digital fieldwork is crucial (Hsu and Chen, 2010). This preparation includes not only familiarising learners with the technology but also helping them develop the skills needed to maximise the learning potential of the digital approach.

Due to the self-directed nature of blended learning environments, there is a bi-modal distribution of learner outcomes (Moore and Gilmartin, 2010), with learners who exhibit effective time management and self-regulatory skills benefiting more from the blended learning environment (Pizzi, 2014; Leatherman and Cleveland, 2020). Frequent interactions are key to maintaining motivation in remote learning settings (Zahariadis and Voliotis, 2003), yet peer interactions and the social construction of knowledge can be challenging to embed within these environments, with facilitators concerned about this loss of interaction and feedback (Bacon and Peacock, 2021; Stagg *et al*., 2022). While digital interactions can be incorporated into both synchronous and asynchronous learning, learners may find these new forms of interaction unfamiliar. Despite extensive use of digital tools in informal contexts (Furlong and Davies, 2012), formal educational interactions such as discussion boards are less frequently used.

The concept of interaction in digital versus in-field settings has been explored; finding that while in-field interactions involve direct engagement with people and places, virtual interactions often focus on time and space (Stainfield *et al*., 2000). This distinction highlights the unique advantages of each interaction type. Although tools like GIS enhance spatial and temporal thinking in geography (Pizzi, 2014), their use in biosciences may be less developed. GIS provides opportunities for spatial and temporal interaction and helps develop key employability skills, such as biological recording and habitat monitoring. This research will seek to develop tools and approaches which support interaction between peers and between peers and facilitators during digital fieldwork.

Research on plant identification indicates that learning in the field is generally more effective than virtual learning (Scott *et al*., 2012). Although this study had a small sample size (n = 8), it suggests that field-based tasks are perceived more positively and yield higher cognitive and affective outcomes compared to virtual tasks. Perhaps the value of digital fieldwork lies in other areas and this research will seek to identify what students and practitioners value in digital fieldwork approaches.

Viewing digital tools as a complementary approach within fieldwork practice is supported within the literature and has a role in enhancing the learning process for learners (Klemm and Tuthill, 2003; Lee *et al*., 2020; Seifan *et al*., 2020; Leininger-Frézal and Sprenger, 2022). Within GEES disciplines, logistics preparation via digital tools such as ArcGIS StoryMaps has improved learner outcomes by linking classroom and the field and offering multiple low-stakes opportunities for skill development (Mukherjee, 2019). Yet this practice is not embedded across all disciplines and has not been explored within the biosciences.

But digital fieldwork poses challenges for learners and facilitators, with the technology posing as a distractor and a barrier (Yeo *et al*., 2020). While simple and accessible solutions, mobile GIS and live streaming, can benefit all learners but may still result in hidden costs related to technology access (Power and Morven-Gould, 2011).

In conclusion, digital fieldwork offers both opportunities and challenges, it is essential to gather feedback from interested and affected parties. This feedback is key to developing digital approaches that address the difficulties faced during in-field fieldwork, find solutions to challenges unique to digital fieldwork and ultimately enhance the overall fieldwork experience for all learners.

1.1.4 Open educational resources for the biosciences

The literature consistently highlights a major barrier to the adoption of digital fieldwork methods is facilitators' lack of knowledge, skills, and confidence (Fletcher *et al*., 2007; Welsh *et al*., 2013). Although these studies were conducted before the Covid-19 pandemic, similar concerns were reflected in a 2020 survey of facilitators, which revealed predominantly negative perceptions of digital alternatives to traditional fieldwork during the pandemic. Notably, *'technology'* emerged as the most frequently cited obstacle to effective remote field teaching (Barton, 2020).

Despite the extensive range of digital fieldwork practices documented in biosciences literature (Barton, 2020; Creech and Shriner, 2020; Edwards and Larson, 2020; McKinnon, 2020; Cowles and Onthank, 2021; Maddison *et al*., 2023a), only a few of these resources are publicly accessible. Most of this digital fieldwork practice within the biosciences are designed for specific institutions, using their in-house systems, and provide only limited guidance on how these resources could be adapted by other institutions or applied in different contexts. In contrast, the geoscience education community has begun to address this gap by developing databases for sharing digital fieldwork Open Educational Resources (OERs), such as VR Glaciers and Glaciated Landscapes (McDougall, 2024), V3Geo (Buckley *et al*., 2022) and other location specific geoscience OERs (Horota *et al*., 2023; Nazarkulova and Strobl, 2023).

V3Geo (Buckley *et al*., 2022) is intended to facilitate the sharing of virtual 3D models for embedding within VFTs for the geoscience community, it offers limited interpretative content. Although the models can be searched spatially via a map function, they are presented without the necessary contextual information beyond the 3D visualisations themselves. This lack of context may present a challenge for facilitators which lack the knowledge and skills to effectively integrate these models into their own VFTs. In contrast, VR Glaciers and Glaciated Landscapes (McDougall, 2024) provides high-quality, 360° interactive linked panoramas, enabling spatial exploration and providing a sense of scale. These web-based resources are easily accessible and user-friendly. However, their design emphasises open-ended exploration in unfamiliar environments through observation, with little to no guided enquiry or specific fieldwork tasks included. Therefore, they do not offer a digital alternative for all of the teaching and learning activities within fieldwork.

1.2 Models and frameworks to support the development and integration of digital tools in fieldwork

There are a number of pedagogy and technology frameworks that can be reviewed and applied to support the development and integration of digital tools in fieldwork. It is vital that both pedagogy and technology are considered, with pedagogy leading the direction of the development through gaining an understanding of the educational situation and the role that technologies can play in it (Laurillard, 2008).

1.2.1 Pedagogy frameworks

1.2.1.1 Experiential learning cycle

Fieldwork inherently offers rich opportunities for discovery-based, active, and real-world learning (O'Connell *et al*., 2020). It is an experiential learning approach using participatory activities (Seifan *et al*., 2020). However, due to constraints related to logistics, residential field trips often become intensive learning experiences with limited time for reflection between stages of the experiential learning cycle (Kolb, 2015). These pre- and post-learning reflections are crucial for maximising learning opportunities for all (Lee *et al*., 2020). Ongoing reflections help learners to better understand their experiences during individual fieldwork activities (Scott *et al*., 2019) and to recognise skill development (Nicotra *et al*., 2022).

The experiential learning cycle (Kolb, 2015) is an underpinning teaching and learning framework that can be applied to fieldwork (Dummer *et al*., 2008). The four stages of this cycle have been applied in numerous studies within fieldwork contexts (Kent *et al*., 1997; Krakowka, 2012; Scott *et al*., 2012). Although the experiential learning cycle has been used to support the development of a blended learning pedagogy to support inclusive geography teaching (McPhee, 2021), there is a gap in the literature on the role that digital tools could play in enhancing this experiential learning cycle during fieldwork. Digital tools were not necessarily widely available previously and as such there was less understanding and identified 'need' for the use of digital tools within fieldwork. Additionally, some perceive technology use as a distractor to the immersive, experiential nature of fieldwork (Smith *et al*., 2016) and as such digital tools are at odds to fieldwork approaches, limiting the collaborative nature of in-field and digital fieldwork approaches.

Building on previous work that applied the experiential learning cycle to specific stages of fieldwork (Healey and Jenkins, 2000; Krakowka, 2012; Scott *et al*., 2012), Figure 1.1 illustrates how digital tools can facilitate learners' progression through the various stages of the experiential learning cycle. This list of activities within Figure 1.1 is not exhaustive, but serves to illustrate how this model could be applied to the process of planning fieldwork, which includes a combination of digital and in-field fieldwork in the different stages of fieldwork.

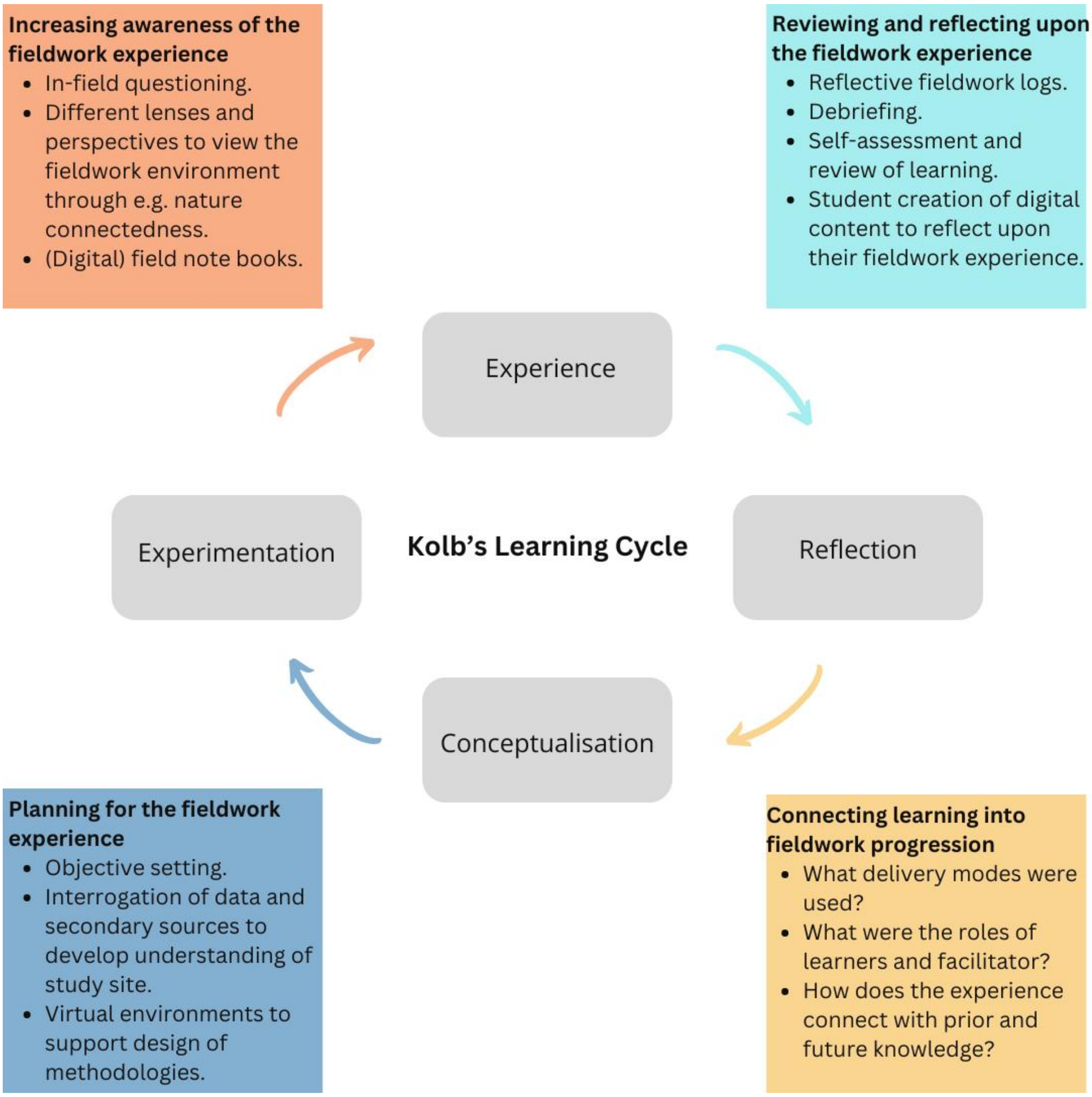

Figure 1.1 In-field and digital fieldwork activities that support learners moving through Kolb's (2015) Experiential Learning Cycle during fieldwork.

1.2.1.2 Community and social learning

A learning community is defined *as 'an intentionally developed community that exists to promote and maximise the individual and shared learning of its members' (*Lenning *et al.*, 2013 in Jessup-Anger, 2015). Fieldwork, being inherently social, naturally fosters the development of interpersonal skills, which are valuable soft outcomes for learners. The principles of a learning community can be specifically tailored and applied to a cohort of learners enrolled in a particular module (Atchison *et al.*, 2019). Drawing on evidence from the literature, Table 1.1 outlines how fieldwork can create opportunities to embed these principles within a learner community.

Table 1.1 A summary of how fieldwork promotes the principles of a learner community.

Principle of the Learning Community		**Examples from the literature of how fieldwork can be used to promote this principle in practice**
1.	Using research to inform practice.	Ensuring principles of inclusive access are embedded and that alternative fieldwork activities or adjustments are available (Houghton *et al.*, 2020; Taylor and Johnson, 2020). Share pedagogic theory behind group approach with learners (Stokes *et al.*, 2012; Rogers, 2020).
2.	Foster bonds between learners and sense of belonging to the collective group.	Development of group through informal field trip activities, and opportunities for inclusion and whole group development through tasks that support an *'inward-trajectory'* from novice to professional (Streule and Craig, 2016). Group fieldwork tasks, learner group establishing criteria for assessment and group formative assessment tasks. (Lonergan and Andresen, 1988).
3.	Engaging learners as active learners as part of the community.	Mini-research projects and sharing of findings through research seminars (Marvell *et al.*, 2013). Contribution to citizen science data collection exercises (Callaghan *et al*., 2022; Pernat *et al*., 2023). Place-based interdisciplinary learning approach via engagement with local stakeholders to gain an understanding of a fieldwork location linking fieldwork to society and local communities (University of Glasgow, 2025).
4.	Create a positive message of achievement and change.	Embed opportunities to identify and develop soft fieldwork outcomes (Peasland *et al.*, 2019). Using learners to co-design field trip objectives, logistics and preparation resources to develop ownership. (Mukherjee, 2019).

5.	Advocating on behalf of the learner for improvement.	Learner evaluation of field trips are undertaken and used to inform future planning (Scott *et al.*, 2019).

While the community and social learning that occurs within in-field fieldwork are well-understood and documented within the literature (Table 1.2), there is a more complex narrative surrounding these within the context of digital fieldwork approaches. Virtual fieldwork fosters situated learning (Duncan *et al*., 2012) by providing an authentic context that enhances social interaction and supports social constructivist learning approaches. While virtual fieldwork facilitates different forms of interaction (Stainfield *et al*., 2000), technology also enables digital engagement (Furlong and Davies, 2012). However, to fully realise the benefits of working in an online community of practice, learners need encouragement and support to identify its value (Klemm and Tuthill, 2003). Although online communities can bridge the gap between experts and learners and free learners from the constraints of time and space (Zahariadis and Voliotis, 2003), the switch to remote learning during the Covid-19 pandemic highlighted significant challenges. Many learners reported feelings of isolation from their peers and a sense of disconnection from their learning experiences due to the lack of on-campus interaction (Bryson and Andres, 2020).

1.2.1.3 The Interactive, Constructive, Active and Passive (ICAP) framework

The Interactive, Constructive, Active, and Passive (ICAP) framework was developed to address the challenges associated with active learning, particularly in adapting existing strategies to enhance active learning and clarify its criteria (Chi and Wylie, 2014). The framework allows for a single activity to be structured in various ways, each fostering different modes of learning and yielding distinct engagement outcomes. By analysing learners' affective responses to tasks, the ICAP framework infers the cognitive engagement involved and provides a hierarchy of active learning activities. The ICAP framework can be applied to fieldwork teaching and learning activities based on their mode of engagement and learner outcome (Table 1.2). Given the frequent concerns about the engagement and interactive nature of digital fieldwork methods (Barton, 2020; Stagg *et al*., 2022), Table 1.2 applies the ICAP framework to an asynchronous VFT.

When designing and implementing any digital tool for fieldwork, it is essential to consider and reflect on learner behaviours during their engagement with the approach. The ICAP framework offers structure to classify learner engagement.

Table 1.2 Applying the ICAP framework to three fieldwork activities, two in-field and one digital (Adapted from Chi and Wylie, 2014).

	Fieldwork Activity		
	Listening to an expert in the field	**Observing a fieldwork methodology**	**Asynchronous Virtual Field Trip (VFT)**
	Learner Behaviours		
Passive.	Learner listening.	Learner watching and listening.	Learner reading and listening to content within a pre-determined linear VFT.
Active.	Learner listening whilst taking verbatim notes from expert.	Learner can repeat method themselves during data collection.	Learner making summary notes from the VFT where learners have control over which aspects of the VFT they engage with and to what extent they engage with it.
Constructive.	Learner creates summary notes, concept map or sketch map of the location. Learner makes their own observation and questions the environment themselves.	Learner is able to justify the methodology, use the method and critically reflect upon that fieldwork method.	Learner complete tasks within the VFT which replicate tasks that may be completed in the field such as creating a sketch map of the fieldwork location from photographs and 360° images or use dichotomous keys to identify species found in the VFT from multiple photographs.

Interactive.	Different hypotheses or viewpoints of a fieldwork location are discussed, with judgement formulated on the relative importance and value of those hypotheses or viewpoints.	Learner acts as a decision maker during the construction of a methodology, they take part in debate with iterative developments of the method.	Learner interacts with their peers and the facilitator of the fieldwork via asynchronous digital communication tools such as discussion boards and community whiteboards where they can post comments, upload documents and receive feedback.

1.2.1.4 'Students as Partners' approach

The SaP approach is an educational ethos and practice where students and educators collaborate (Healey *et al*., 2014). The level of partnership can be defined in various ways, including student representation or participation (McCulloch, 2009; Matthews and Dollinger, 2022), a framework based on values that promote partnership (Healey *et al*., 2016), and the use of a ladder of student participation in curriculum design (Bovill and Bulley, 2011).

There are a number of benefits to engaging students in co-design processes. These include increased awareness of teacher-student roles (Garcia *et al*., 2018), a deeper understanding of the role of collaboration (Prescott *et al*., 2020; Woods and Homer, 2021), and the development of essential graduate skills (Pauli-Hones *et al*., 2016).

Although this partnership approach has been identified as enhancing student reflection on the learning process when using digital tools (Senger and Nordmo, 2021) and supports inclusive practices in fieldwork education (Lawrence and Dowey, 2022), within the literature there are limited examples of students being involved in developing and integrating digital fieldwork approaches (Welsh *et al*., 2013; Gros and López, 2016).

By applying the SaP framework to the design and development of digital fieldwork and working with students at differing levels of partnership, this research seeks to address the student engagement challenges of digital fieldwork (Barton, 2020; Stagg *et al*., 2022) and create engaging, learner-centred digital tools which can be used in fieldwork.

1.2.2 Technology frameworks in education

There are several relevant technology frameworks that can be used to support the integration of digital tools in fieldwork (France *et al*., 2020) or education more broadly (Koehler and Mishra, 2005).

1.2.2.1 Technological Pedagogical and Content Knowledge (TPACK) Framework

Building on the Pedagogic Content Knowledge framework (Shulman, 1987), the Technological Pedagogical and Content Knowledge (TPACK) framework was developed by Koehler and Mishra (2005). TPACK offers an integrated approach that examines how deep knowledge of technology, pedagogy, and subject content interact, and how understanding these interactions can support the integration of technology to address challenges and enhance learning (Koehler and Mishra, 2005; Voogt *et al*., 2013). Reflections from science and geography teachers on digital fieldwork during Covid-19 have been applied to the TPACK framework, illustrating how teachers adapted their pedagogic content knowledge for new digital delivery methods (Stagg *et al*., 2022). Involving learners in the integration and creation of digital tools in education has yielded mixed results.

While studies show that learners enjoy using digital tools to create their own blended learning resources (Mukherjee, 2019; Treves *et al*., 2021; Tian *et al*., 2022), they also highlight that this process can be challenging (Mukherjee, 2019), with technical difficulties (Treves *et al*., 2021) and the requirement of extensive onboarding or training (Tian *et al*., 2022). These findings highlight the importance of this research in drawing upon the experiences of HE learners to better understand and support the integration of the digital tools and enhances existing work by applying these insights to the TPACK framework.

In looking broadly at generalised models of technology acceptance, there are several factors that are identified as influencing users' willingness to adopt new technologies. These are the ease of use, perceived usefulness, and the role of social influence (Davis, 1989; Marikyan and Papagiannidis, 2023). In educational settings, perceived usefulness plays a crucial role in behavioural change and technology acceptance, in particular in the adoption of OERs (Teo, 2009; Kuo *et al*., 2024). Research on fieldwork education identifies that effective training is essential for building the skills and confidence needed to use digital tools, as staff time and expertise are barriers to technology adoption (Fletcher *et al*., 2007; Welsh *et al*., 2013).

According to Martec's Law (Brinker and McCellan, 2014; Brinker, 2016; 2020), the shift to digital technologies is a disruptive process driven by rapid technological advancements and corresponding organisational changes. The Covid-19 pandemic exemplifies this disruption, forcing educational institutions to rapidly adopt digital solutions (Barton, 2020; Whalley *et al*., 2021). This research is timely, leveraging the experiences and skills developed during this period of the Covid-19 pandemic to enhance the integration of digital tools in fieldwork.

1.2.2.2 The Pathways Diagram

The Pathways Diagram (France *et al*., 2020) supports the adoption of mobile technologies in fieldwork education by integrating a pedagogical framework with technological considerations. It is a comprehensive tool that enables facilitators to reflect holistically on mobile learning within fieldwork. However, it does not offer a link between the pedagogical framework and the technological logistics identified within the framework. Introducing a bridging question, such as *"Does the proposed benefit of the intervention outweigh the associated costs of time and expenditure?"* could be beneficial.

Additionally, instead of having two starting points, a single starting point that allows facilitators to identify a specific pedagogical challenge would better focus the intervention on pedagogy. This focus on identifying a specific pedagogical challenge, guides the development of the digital tools within this research. Ensuring that the adoption is driven by educational needs rather than technology, which aligns with key recommendations for integrating technology-enhanced learning in fieldwork (Fletcher *et al*., 2002; Welsh *et al.*, 2013; Burden, 2017; Rogers, 2020; Shinneman *et al*., 2020).

1.2.2.3 Digital Technology in Outdoor Experiential Learning (DTOEL)

Beyond the use of mobile devices in fieldwork (France *et al*., 2020), a broader approach for the adoption of digital technology is provided by the Digital Technology in Outdoor Experiential Learning (DTOEL) framework, which has been constructed through the review of case studies within the literature (Hills and Thomas, 2020).

Similar to TPACK, the DTOEL framework emphasises the importance of pedagogy, but it goes further by offering a detailed scaffold with six key pedagogical considerations (1. Overall context, 2. Session objectives, 3. Technology users, 4. Facilitator attributes, 5. Learner attributes, and 6. Available resources). DTOEL is designed to guide the planned use of digital technology in a pedagogically driven manner, evaluating individual aspects of the technology and considering its consequences. These consequences are examined through the

Substitution, Augmentation, Modification, and Redefinition (SAMR) model (Puentedura, 2006; 2013; Romrell *et al*., 2014). Integrating SAMR within the broader framework of Pedagogical Considerations (Section A) addresses the contextual limitations often associated with the SAMR model (Hamilton *et al*., 2016).

Although the DTOEL framework (Hills and Thomas, 2020) and its use of SAMR can be critiqued as somewhat subjective (Hamilton *et al*., 2016), it can serve effectively as a decision-making tool, similar to the Pathways Diagram (France *et al*., 2020). The DTOEL framework facilitates discussions and consultations regarding technology adoption and provides a comprehensive approach to decision-making in digital technology integration. This research will leverage the DTOEL framework to support the evaluation and dissemination of digital tools within fieldwork, by using some of the same language associated with the framework. This offers the opportunity to highlight and exemplify key aspects of the DTOEL framework in practice via this research.

1.3 General research aims

Both learners and facilitators have experienced a significant shift in fieldwork practices, accelerated by the Covid-19 pandemic. This research aims to build on that momentum by capturing critical perspectives on both traditional in-field and digital fieldwork approaches and using these to develop digital fieldwork tools which can be integrated within existing fieldwork practice. This research hypothesises that digital tools can enhance fieldwork and can be integrated within HE fieldwork teaching in the biosciences.

This research seeks to deepen our understanding of digital delivery modes, exploring how expanded definitions of fieldwork can be integrated into existing models of fieldwork practice. The concept of the 'learner community' within these digital fieldwork contexts will also be further explored within this research. Additionally, this research also aims to develop a new, inclusive fieldwork taxonomy that can guide the planning of progressive fieldwork experiences.

Informed by this initial exploration, the second phase will investigate the extent to which students can be involved in designing digital tools to address specific identified pedagogical challenges in fieldwork. An iterative design process will be used to develop three distinct digital fieldwork approaches for use within the biosciences in HE.

The concept of student partnership will be further investigated by collaborating with small groups of students in a co-production partnership. Together, they will design, develop, and deliver fieldwork using live broadcast methods. This partnership will be evaluated, considering the overall experience and skills developed. The future role of this novel delivery mechanism within fieldwork will also be considered.

Finally, this research aims to disseminate key findings and provide guidance based on the study's outcomes. Adhering to the action research (AR) ethos, it will capture case studies and highlight actions taken by the broader fieldwork community to integrate digital tools into fieldwork, ultimately enhancing the overall experience.

Building on recommendations to transform field-based sciences in response to Covid-19 through digital archives and open science principles (Scerri *et al*., 2020), this research aims to address this resource gap within the biosciences by developing publicly accessible digital fieldwork resources. In attempting to address the issue faced by some institutions that do not possess the skills needed to develop their own digital fieldwork approaches (Guillaume *et al*., 2023), this research will also attempt to address issues of staff knowledge and skills (Fletcher *et al*., 2007; Welsh *et al*., 2013) and the digital divide in educational technology (Afzal *et al*., 2014) by offering sector-wide training workshops. These workshops will introduce the newly developed resources, foster participatory discussions on their use, and address practical challenges. The effectiveness of these workshops will be evaluated based on increased knowledge and enthusiasm for adopting digital resources.

Although the factors that influence the willingness to adopt technologies in education are well-understood, there is limited research addressing the development and integration of digital tools in fieldwork. This research aims to explore current fieldwork practice to inform the design of digital tools that address specific pedagogical challenges (Chapter 2). Collaborating with students, the digital tools will be evaluated and refined to enhance the usability of the tool (Chapters 3 and 4), with the impact of one of these tools evaluated (Chapter 5). Finally, drawing upon the concept of social influence, participatory workshops will facilitate the dissemination of these tools within the broader fieldwork community. These workshops will offer opportunity to discuss the tools with a focus on adoption and adaptation (Chapter 6).

Although the Pathways Diagram (France *et al*., 2020) is designed to support the integration of mobile technologies in fieldwork, this research draws upon this framework more broadly. It does this by considering the technology logistics and underlying pedagogy within the design and development of all four digital tools within this research (Chapters 3 and 4), with this same focus guiding discussions within the sharing stage of this research (Chapter 6).

Working with students within this research is important, as the perception of a digital approach can influence the success of its integration (Moore and Gilmartin, 2010; Marikyan and Papagiannidis, 2023). Within this research a SaP approach has been combined with the views and experiences of fieldwork practitioners. This is to ensure that the digital fieldwork development fulfils an identified pedagogic need, rather than focusing technology innovation.

1.4 Overall context underpinning this research

The research is primarily qualitative, aiming to uncover the behaviours and experiences associated with both traditional in-field fieldwork and the emerging practice of digital fieldwork. These complex insights are unlikely to be fully captured through quantitative methods alone, but where possible quantitative analysis is used to support the rich, descriptive nature of the qualitative data. This research seeks to explore how digital fieldwork is defined, as well as identify the factors that contribute to the effectiveness of integrating digital tools in fieldwork education.

The exploration phase of this research (Chapter 2) adopts a broad approach, engaging with interested and affected parties across the wider fieldwork sector to inform the subsequent stages of the study. The design elements follow an Action Research approach (Chapters 3 and 4) and are grounded in biosciences fieldwork within HE, with a focus on the experiences of Newcastle University Marine Science and Ecology students. One of these digital tools (Digital Field Notebook) is then embedded within biosciences fieldwork at Newcastle University, with the impact of this integration explored (Chapter 5). The final stage, involving sharing and dissemination, once again takes a broad approach, extending the application of the digital tools to the wider fieldwork community, demonstrating their versatility across diverse contexts (Chapter 6).

As anticipated, Covid-19 is a recurring theme throughout all phases of this research. This research began during Covid-19 and under lockdown restrictions. Even as restrictions have eased and in-field fieldwork has resumed, both practitioners and student participants within this research have consistently referenced their experiences with digital fieldwork during the pandemic across every phase of the research.

1.5 Significance of this research and original contributions

Learner voices are often absent from research that examines both the barriers to fieldwork (Cook *et al*., 2006; Scott *et al*., 2015) and the integration of technology in fieldwork (Welsh *et al*., 2013). With students actively participating via a SaP approach in this research, the qualitative data offers valuable insights into students' experiences using digital tools in fieldwork. This research provides insight into what they value in the digital tools such as the sense of immersion, digital skill development opportunities and their role in preparing for in-field fieldwork. These student experiences are particularly significant given that this current generation of HE learners have navigated significant upheaval and transformation in their education due to Covid-19.

While maintaining a focus on pedagogy and using low-tech, low-cost digital tools, this research has trialled delivery modes within the biosciences that are currently under-explored within the literature. Live broadcasting is a tool with limited application outside a single fieldwork organisation (Stagg *et al*., 2022) and institution (Brown *et al*., 2023; Open University, 2023), where in both contexts' experts deliver content to novice learners. Drawing inspiration from these examples, this research has collaborated with students to co-design, co-develop, and co-deliver live fieldwork broadcasts. This peer-to-peer digital fieldwork opportunity offers unique benefits, including enhanced engagement and opportunity for science communication and digital skill development.

The fieldwork taxonomy and the three-step planning tool developed in this research provides, to the best of the author's knowledge, the most comprehensive criteria to date for defining the broad range of fieldwork practice across disciplines. The aim of this tool is to help facilitators across the fieldwork sector to use a common language to define and plan progressive fieldwork experiences.

Recent publications have emphasised the need to address EDI challenges within fieldwork (Kingsbury *et al*., 2020; Lawrence and Dowey, 2022). Informed by fieldwork EDI best practice and recommendations (Zavaleta *et al*., 2020; Yorke *et al*., n.d), this research places EDI at the heart of the development process of the digital tools. It does this by drawing upon various

EDI lenses to guide both the development and interpretation of themes identified in the data. This includes the author's reflection on how each of the three developed digital tools addresses the five key barriers to fieldwork - financial, information and knowledge, past opportunity, identity, commitment, and personal circumstances (Zavaleta *et al*., 2020). Additionally, through student partnerships, an iterative design process, and a proactive approach to overcoming identified challenges, this research aligns with the core principles of inclusive design: anticipatory, flexible, accountable, collaborative, transparent, and equitable (Morgan and Houghton, 2011).

1.6 Summary

To address the hypothesis that digital tools to enhance fieldwork can be integrated within HE fieldwork teaching in the biosciences this research will address the following research aims (RA):

- RA1. Define digital fieldwork and use this to broaden existing models of fieldwork (Chapter 2).
- RA2. Consider to what extent can students be involved in designing digital tools to address pedagogic challenges and enhance fieldwork (Chapter 3).
- RA3. Explore the impact of working in a partnership with students to deliver fieldwork using live broadcast methods (Chapter 4).
- RA4. Identify the impact of using a digital tool during fieldwork (Chapter 5).
- RA5. Share key findings and guidance within the wider fieldwork community with the aim of increasing knowledge, inspiring others and working to support the integration of digital tools within fieldwork (Chapter 6).

Chapter 2. Models of fieldwork post-Covid-19

Abstract

Despite fieldwork practice evolving since the onset of the Covid-19 pandemic, with an increase in digital delivery approaches of fieldwork, definitions of fieldwork do not accurately describe the broad range of fieldwork practice within the biosciences and geography, earth, and environmental science disciplines. The literature presents a complex picture on the value of digital fieldwork, but much of this is based on pre-pandemic studies.

Conducting a review of the literature and using expert panel interviews, a fieldwork practitioner survey, student focus groups and participatory workshops this research examines the practice of fieldwork post-Covid-19.

A diverse list of fieldwork activities was shared by practitioners. In reviewing the underlying pedagogic approach and the delivery mechanism used to deliver the fieldwork, a taxonomy of fieldwork was constructed that can be used to define the current practice in fieldwork.

Student-identified priorities of digital fieldwork include the opportunity to develop digital skills and a feeling of immersion when using the digital tools. Students identified that digital fieldwork should be used to both address access and equity issues in fieldwork, and to better prepare for fieldwork.

Within this research practitioners strongly identified value in the necessity of in-person fieldwork but shared a mixed-picture on the necessity of digital fieldwork. Although they did identify value in digital tools to offer wrap-around support, prepare students and develop digital skills.

There was very little overlap in the practitioner identified challenges and opportunities of both in-field and digital fieldwork, supporting a view that digital fieldwork is not a direct replacement for in-field fieldwork but offers alternative opportunities that may be difficult to achieve during in-field fieldwork.

2.1 Introduction

2.1.1 Definitions of fieldwork

Fieldwork is a catch-all term that encompasses a wide variety of tasks. Classifying fieldwork practice has been previously considered in the literature with a timeline of change observed (Lonergan and Andresen, 1988), with each fieldwork 'era' defined by its own characteristics of the approach (Kent *et al*., 1997; Fisher, 2001). Whilst Kent *et al*., (1997) reviewed geography fieldwork in Higher Education (HE), Fisher (2001) reviewed science fieldwork in schools. Both reviews showed similarities in the cumulative change and growth of fieldwork provision over time. Table 2.1 summarises this timeline of cumulative change and adds comments on the underlying pedagogy of the approach and deduced learner outcomes. It also includes a brief summary of the improvisation and pivot to digital fieldwork in response to the Covid-19 pandemic (Bryson and Andres, 2020). Since the 1990s fieldwork has encompassed a variety of observational and enquiry approaches, which provide opportunities for learners to gain subject knowledge and develop both fieldwork and transferable skills via progressive learning throughout a field trip (Kent *et al.,* 1997; Fisher, 2001).

Table 2.1 Cumulative changes in fieldwork. (Adapted from Kent et al., 1997; Fisher, 2001; Bryson and Andres, 2020).

Era	Fieldwork Approach	Pedagogy	Learner Outcomes
1950-1960s.	Cook's Tour- Observation Fieldwork.	Passive learner engagement. Staff as expert.	Subject knowledge.
1970s.	Projects- Problem Based Fieldwork.	Fieldwork through enquiry. Positivist. Staff-led projects.	Subject knowledge. Fieldwork skills.
1985.	Transferable Skills through Projects-Problem Based Fieldwork.	Fieldwork through enquiry. Positivist. Learner-led projects.	Subject knowledge. Fieldwork skills. Employment skills.
1990s.	Field courses encompassing variety of approaches.	Progressive fieldwork experiences.	Subject knowledge. Fieldwork skills. Employment skills.
2020 (expedited by Covid-19).	Rapid pivot to digitisation of a fieldwork environment.	Improvisation of online teaching to curate intensive and extensive experiences.	Understanding of topic and issues and critically review evidence to inform analysis.

2.1.2 Pivot in fieldwork delivery mode during Covid-19 pandemic

With the onset of Covid-19 in March 2020, there was a rapid substitution of in-person teaching to online provision (Bryson and Andres, 2020). In fieldwork, the travel restrictions, closure of in-person education operations and lockdown procedures resulted in in-person fieldwork being cancelled (Creech and Shriner, 2020). Many institutions rapidly transitioned their fieldwork offer to virtual, digital, or at-home fieldwork delivery modes. These alternatives included, for example, ‘lab in a box’ (Novo *et al*., 2021), self-guided trips (Middlebrooks and Salewski, 2021), asynchronous virtual field trips (Friess *et al.,* 2016), synchronous virtual field trips (Dolphin *et al*., 2019; Cowles and Onthank, 2021), augmented reality applications to visualise 3D models (Rogers, 2020; Verdes *et al*., 2021), live broadcasting to delivery fieldwork via YouTube Live (Stagg *et al*., 2022) and fieldwork located in learners’ own gardens (Bacon and Peacock, 2021). Yet facilitators noted that these substitutions were more instructor centred, with a reduction in the learning outcomes when compared to the in-person/in-field fieldwork alternative (Barton, 2020).

This pivot in delivery mode, with increased uptake of digital delivery, means that Butler’s (2008) definition of fieldwork as *“all outdoor teaching and learning activities”* is lacking accuracy, as it does little to define the diverse and broad range of practice currently present within fieldwork.

2.1.3 Defining fieldwork post-Covid-19

Fieldwork can be classified on the type of fieldwork activity that is undertaken (Butler, 2008; Krakowka, 2012). While this is descriptive and showcases the nature of the fieldwork activities, no information is given on the relationship between individual opportunities of fieldwork activities. Alternatively, relational classifications of fieldwork help to support facilitators to develop fieldwork approaches that build progression in fieldwork knowledge and skills for learners. The role of the learner and the facilitator are shown in two subject specific relational fieldwork approaches; in geography (Oost *et al.,* 2011) and in biosciences (Peasland *et al*., 2019). Both models enable pathways of learner development to be identified with learners increasing in confidence and autonomy. However, both models do not consider the broad range of delivery modes and pedagogic approaches present within fieldwork post-Covid-19.

Although some pre-pandemic models of digital fieldwork practice exist (Klemm and Tuthill, 2003), these are often focussed on the technology used to deliver the approach and not the underlying pedagogy. Such a focus may limit the effectiveness and uptake of these approaches, with perceived barriers of the technology outweighing any potential pedagogic gains. Those models that place pedagogy at the heart of the decision-making process of integrating technology in fieldwork (Hills and Thomas, 2020; France *et al*., 2020) do so in isolation of in-field approaches and reinforce this distinction between digital and in-field fieldwork. This may result in facilitators facing an artificial choice between digital and traditional in-field fieldwork approaches, rather than considering how both could work together.

There is a disconnect between learners' and facilitators' views on the rationale and value of field courses (Woodly *et al*., 2024), this is mirrored in digital fieldwork, where the literature shows a complex picture of the role and value of digital fieldwork. Although facilitators note that using technology throughout the fieldwork process provides benefits such as efficient data processing, the development of learners' digital skills (Welsh *et al*., 2013), increasing access and inclusion (Smith and McNeal, 2023) and meaningful contribution to learning (Medzini *et al*., 2015), digital fieldwork tools such as Virtual Field Trips (VFTs) have been cited as one of the reasons for a decline in the quantity of fieldwork undertaken (Maw *et al*., 2011) with the need to leave the classroom for fieldwork removed (Boyle *et al*., 2007). Some consider that they are an inadequate replacement to in-field approaches (Smith and McNeal, 2023), with limited/no impact on overall learning outcomes (Juergensmeier *et al*., 2024), and that the technology a distractor in fieldwork (Smith *et al*., 2016). In contrast, others see it as complementing existing fieldwork practice (Stokes *et al*., 2012; Leininger-Frézal and Sprenger, 2022) with virtual fieldwork acting as a valuable additional link between the classroom and the field (Thorndycraft *et al*., 2009; Edwards and Larson, 2020). Acceptance of virtual fieldwork environments was found to be higher in facilitators than in undergraduate learners, with facilitators finding these approaches more useable (Puhek *et al*., 2013). Although HE learners identified that virtual fieldwork was enjoyable and a good way to learn, they did not view it as an acceptable replacement to fieldwork (Spicer and Stratford, 2001), with bioscience students preferring in-person and blended approaches over online options during the Covid-19 pandemic (Mehta *et al*., 2024). Although other studies have identified that virtual fieldwork improves intrinsic motivation of students (Juergensmeier *et al*., 2024).

The recent shift to digital delivery modes of fieldwork (Bryson and Andres, 2020; Creech and Shriner, 2020) mean that a broadened field of practice exists within fieldwork post-Covid-19 (Creech and Shriner, 2020; Cowles and Onthank, 2021; Verdes *et al*., 2021) with learners and facilitators both having experience of navigating this shift. Some fieldwork now incorporates a combination of digital and in-field approaches (McKinnon, 2020; Lee *et al*., 2020; Geange *et al*., 2021; Nicotra *et al*., 2022), yet these represent case studies of individual institutions which do not represent embedded practice throughout bioscience fieldwork in HE and do not use a common language to describe this fieldwork practice.

Opportunities to capture interested and affected parties' views are vital as much of the literature focuses solely on facilitator views (Barton, 2020; Bryson and Andres, 2020; Scerri *et al*., 2020; Firomumwe, 2022) or small number of learner views (West *et al*., 2023). These views should be actively sought as we consider the role and value of digital tools within fieldwork and support the transition to an integrated model of fieldwork which utilises both in-field experiences alongside digital fieldwork components.

A consistent and accepted terminology for this broadened field of practice is yet to be established within the geosciences (Foley *et al*., 2024) or the biosciences. Even within VFTs there is variety in both the pedagogy and technology resulting in different outputs (Leininger-Frézal and Sprenger, 2022). There is a need for a holistic non-subject specific classification system that can be used to define this broad practice within fieldwork post-Covid-19. Inspired by the notes within a review of virtual worlds usage in education (Duncan *et al*., 2012) it should focus both on the *activity* (or delivery mechanism) and the *learning theories* (or pedagogic approach) to define the fieldwork practice. Such a classification system would seek to use a common language to define practice and enable a holistic taxonomy of fieldwork opportunities to be identified. This holistic taxonomy of fieldwork would aim to shift the focus away from competition between delivery modes, to one which enables progression to be planned where variety in delivery mode can support diverse learners and help to increase equality and inclusion within fieldwork disciplines (Cooke *et al*., 2020); an identified challenge present within fieldwork (Beltran *et al*., 2020; Zavaleta *et al*., 2020).

2.1.4 Research aim and objectives

The overarching research aim (RA) of this chapter is to define digital fieldwork and use this definition to broaden existing models of fieldwork (RA1). To address this aim, this chapter will focus on two research objectives (RO). First, it will define post-Covid-19 fieldwork practice in terms of delivery mechanism and pedagogic approach (RO1.1). Second, it will evaluate how digital fieldwork is viewed and valued by interested and affected parties (RO1.2).

2.2 Methods

2.2.1 Review of the literature

This research seeks to create a non-discipline specific classification system of all fieldwork practice. Using the principles outlined in Cohen (2018), a post-positivist review of the literature was used to construct a coherent understanding of fieldwork practice within HE. A comprehensive search strategy and abstract mining using inclusion and exclusion criteria was undertaken in May 2021 for articles published in 2000-2020, and again in October 2024 for articles published in 2021-2023, with Scopus identified as an appropriate data base (Table 2.2). As fieldwork is a signature pedagogy within both the biosciences, and geography, earth, and environmental science (GEES) disciplines (Munge *et al.*, 2017), two searches were conducted each time.

For the biosciences a total of 306 papers (254 between 2000 and 2020; 52 between 2021 and 2023) were identified and reduced to 58 (45 between 2000 and 2020; 13 between 2021 and 2023). For GEES a total of 394 papers (344 between 2000 and 2020; 50 between 2021 and 2023) were identified and reduced to 124 (100 between 2000 and 2020; 24 between 2021 and 2023). This resulted in a total of 182 articles for analysis. The abstract screening was undertaken using the inclusion and exclusion criteria identified in Table 2.2.

A full review of these 182 articles was undertaken to determine the frequency of five overarching fieldwork delivery modes (In-field, Blended, Virtual, Technology in Field and Augmented Reality) between the years 2000-2023, and to identify the pedagogic approaches and delivery mechanisms used within fieldwork.

A review of the 145 articles (2000-2020) was undertaken to identify the defining characteristics of digital fieldwork, which informed subsequent digital fieldwork design work undertaken in Chapters 3 and 4.

Table 2.2 Details of the search terms used on SCOPUS (Elsevier, 2024) and the inclusion/exclusion criteria used within the abstract review.

	Biosciences	Geography, Earth, and Environmental Sciences
Search terms.	(bioscience OR ecology OR biology} AND {"Higher Education" OR university} AND {Fieldwork OR "Virtual fieldwork" OR "Field trip" OR "virtual reality" OR "m-fieldwork" OR "digital fieldwork" OR "m-learning" OR blended).	(GEES OR geography OR geology OR earth science" OR "environmental science"}AND {"Higher Education" OR university} AND {Fieldwork OR "Virtual fieldwork" OR "Field trip" OR "virtual reality" OR "m-fieldwork" OR "digital fieldwork" OR "m-learning" OR blended).
Abstract review.	**Inclusion criteria**	**Exclusion criteria**
	Published in English.	Published in a language other than English.
	Must be original research papers, review papers or case studies.	Opinion articles.
	Published after the year 2000.	Published before the year 2000.
	Quantitative or qualitative methodology using descriptive or experimental designs.	No relevance to Higher Education fieldwork teaching.

2.2.2 Expert panel interviews

Semi-structured interviews (n = 10) were conducted with identified *'leaders of the field'* (utilising direct knowledge of the fieldwork sector) to support the defining of the post-Covid-19 fieldwork practice and to determine how fieldwork is viewed and valued by these individuals.

Representatives from diverse HE institutions (Table 2.3) with contrasting fieldwork and digital teaching experiences were sought, alongside teaching and learning colleagues within subject associations and experts from industries involved with practical fieldwork and digital tools to support fieldwork.

Semi-structured interviews (Appendix 2.1) enabled participants to share their background and experiences within fieldwork, as well as their views on the purpose, challenges and opportunities present within fieldwork and digital fieldwork. Many also shared and reflected upon their knowledge of other institutions and organisations fieldwork experience.

Table 2.3 Job roles of the expert panel interview participants.

Participant Code	Role
EXP A.	Industry (Environment Agency).
EXP B.	Subject Association/Industry (Field Studies Council).
EXP C.	Subject Association (British Ecological Society).
EXP D.	Subject Association (Geographical Association).
EXP E.	Higher Education (Cardiff University).
EXP F.	Higher Education (Open University).
EXP G.	Subject Association (Royal Geographical Society).
EXP H.	Higher Education (Manchester Metropolitan University)/ Industry (Ecological Consultancy).
EXP I.	Teaching and Learning Community.
EXP J.	Industry (ESRI UK).

2.2.3 Fieldwork practitioner survey

The themes and findings from the expert panel interviews helped to inform the construction of the fieldwork practitioner survey. This survey had open questions to capture the challenges experienced and the under-utilised opportunities of both in-field and digital fieldwork. Closed questions were used for participants to share the different types of fieldwork approaches they facilitated, to self-evaluate the in-field and digital fieldwork experiences they had previously facilitated and to define the purpose of both in-field and digital fieldwork. With the responses available in these 'purpose' questions coming directly from the themes identified within the expert panel interviews.

The fieldwork practitioner survey (Appendix 2.2) was promoted through Newcastle University School of Natural and Environment Science Academic Groups, Newcastle University Teaching and Learning Groups, British Ecological Teaching and Learning Special Interest Group, Enhancing Fieldwork Network, Field Studies Council education network, Nature Friendly Schools education network, geography and science 14–18-year-old teacher networks and through X (previously Twitter).

2.2.4 Student focus groups

Student focus groups (n = 4) (Appendix 2.3) were conducted with a total of 22 participants, across different stages of study, using an adapted nominal focus group technique (NFGT) (MacPhail, 2001; Varga-Atkins *et al*., 2017). This method was used to specifically capture both individual reflections and views (Stages 1 and 3) as well as providing an opportunity for group discussion (Stage 2), the identification of group priorities alongside ideas for enhancement of provision (Stage 4) and finally further discussion (Stage 5). Figure 2.1 summarises the adapted NFGT technique with a copy of the focus group schedule is included within Appendix 2.3.

Fourteen participants were current Newcastle University students; six were postgraduate students enrolled on a Habitat Monitoring and Assessment module, three second year undergraduate students undertaking a Residential Field Course module and five second year undergraduate students enrolled on a Marine Practical Skills module. Focus groups were held in person with student volunteers during residential field courses. Each focus group was audio recorded with a whiteboard used to record participant contributions.

An online focus group hosted via Zoom was held with eight members of the Field Studies Council (FSC) Youth Council who were invited to attend on a voluntary basis. The FSC Youth Council is a group of young naturalists aged 16-25 from across the UK who act as representatives for other young people who engage with the FSC. This focus group was conducted with FSC's Youth Engagement Officer present, for parity the session was recorded, with a shared digital whiteboard used to record participant contributions. All focus groups lasted between 60 minutes and 90 minutes, with recordings subsequently transcribed and taken forward for analysis.

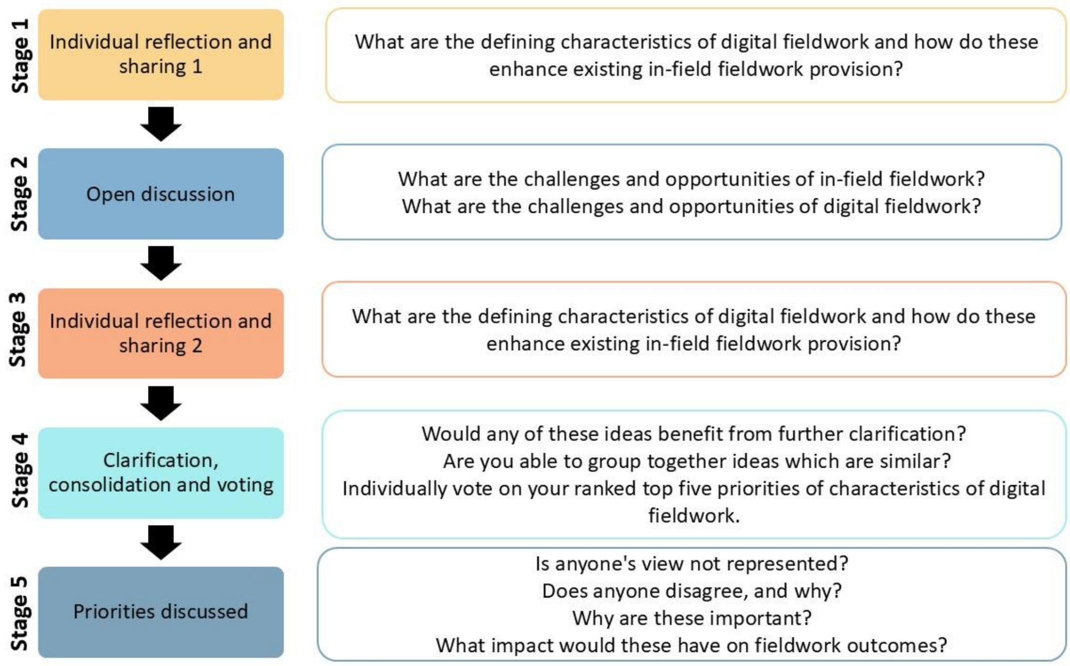

Figure 2.1 Adapted Nominal Focus Group Technique (NFGT). Stage 1: Participants given time for individual reflection on the defining characteristics of digital fieldwork and how these enhance existing in-field fieldwork provision. Participants take it in turn to share all their ideas, which are recorded visually for the whole group to see. Stage 2: Open discussion on the challenges and opportunities of in-field and digital fieldwork. Stage 3: Revisit of Stage 1 questions, with further personal reflection time and individual sharing of additional defining characteristics. Stage 4: Participants discussed the collated defining characteristics asking for clarification from their peers where needed. The list was consolidated with similar characteristics grouped. Participants asked to choose their top five priorities for the defining characteristics of digital fieldwork, awarding their first choice five points, second choice four points, third choice three points, fourth choice two points and fifth choice one point. Stage 5: Total points are calculated with the groups top 5 priorities being identified and then discussed.

2.2.5 Participatory workshops

Student workshops (n = 3) were conducted with a total of 22 participants. All participants were second year Newcastle University students participating in a field-based ecology module. Workshops were held in person and audio recorded, with student volunteers during the residential field course aspect of the module.

A workshop task was set following the protocol below:

1. Introduction of the different learning activities within the model (Table 2.4).
2. Workshop participants invited to discuss their experiences of these learning activities within the module.
3. Participants were tasked with placing these individual learning activities on a graph axis depicting learner and facilitator roles (Figure 2.2).

4. A discussion was facilitated where participants could share what knowledge, skills and/or behaviours they think were developed during these different learning activities within the module.

Table 2.4 Summary of the teaching and learning activities for the field-based ecology module.

Code	**Activity/Session**	**Mode of delivery**
1.	Overview of module.	In-person lecture and discussion.
2.	Fieldwork planning and preparation. Teamwork and inclusivity.	In-person lecture and discussion.
3.	First aid, health, and safety. Mental health, wellbeing and belonging.	In-person lecture and discussion.
4.	Virtual habitat- marine.	In-person workshop using virtual fieldwork resources.
5.	Digital Field Notebook and recording data in the field.	In-person lecture and discussion.
6.	Information on individual projects	Lecture.
7.	Virtual habitat- woodland and freshwater.	In-person workshop using virtual fieldwork resources.
8.	Mapping in the field & app recording.	Lecture.
9.	Gosforth Nature Reserve field visit.	In-person fieldwork.
10.	Intro to R- reading in data.	Workshop.
11.	Meet your project groups.	Hybrid small group seminar.
12.	Group planning.	Hybrid small group seminar.
13.	Millport residential fieldwork.	In-person fieldwork.

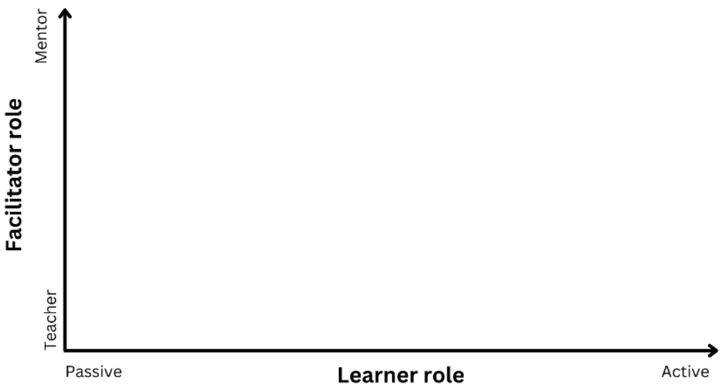

Figure 2.2 Axes used to define learner and facilitator roles during fieldwork (adapted from Kent et al., 1997; Panelli and Welch, 2005; Herrick, 2010; Peasland et al., 2019).

2.2.6 Data analysis

This research produced quantitative and qualitative data from a review of the literature, expert panel interviews, fieldwork practitioner survey, student focus groups and participatory workshops. Table 2.5 summarises the quantitative and qualitative data analysis undertaken for each of these methods and how these relate to each of the research objectives. This combination offers a comprehensive and holistic view of the research data. The quantitative analysis methods give insight into trends and relationships, and the strength of these, while the qualitative data analysis enables us to understand these data, with rich interpretation of participants' experiences on this subject.

Table 2.5 Summary of the data analysis undertaken within this research and how it relates to each aspect of the method and research objectives (RO).

RO	**Methods**	**Data analysis**
How can post-Covid-19 fieldwork practice be defined? (RO1.1).	Review of the literature.	Deductive content analysis to determine frequency of overarching fieldwork delivery modes between the years 2000-2023. Inductive content analysis to determine a list of pedagogic approaches and delivery mechanisms for fieldwork practice between the years 2000-2023. Inductive content analysis to identify the frequency of defining characteristics to describe digital fieldwork approaches, these characteristics are summarised by overall approach (blended, technology in field and virtual) in the literature between the years 2000-2020. Spearman's Rank correlation coefficient was applied to the results of the deductive content analysis using an applied correlation matrix. First, this comparative analysis examined the correlation between each delivery mode and year, identifying whether its inclusion in the literature had significantly increased or decreased over time. Second, it analysed the correlation between the annual frequency of each fieldwork delivery mode within the literature.[1]
	Expert panel interviews.	Inductive content analysis to determine a list of pedagogic approaches and delivery mechanisms for fieldwork practice.
	Fieldwork practitioner survey (open questions).	

	Participatory workshop.	Summary of key differences and similarities between proposed progression of the fieldwork module and the realised experience of students within the participatory workshops.

Evaluate how digital fieldwork is viewed and valued by interested and affected parties (RO1.2).	Expert panel interviews.	Inductive content analysis to determine the frequency of challenges and opportunities of both in-field and digital fieldwork approaches.
	Fieldwork practitioner survey (open questions).	Reflexive thematic analysis[2] to summarise the identified themes of the challenges and opportunities of in-field and digital fieldwork. Using the results of the inductive content analysis (frequency of individual challenges and opportunities of both in-field and digital fieldwork approaches), Principal Component Analysis was undertaken to determine which of the themes can be attributed to the driving forces of of 'Challenge: In-field', 'Challenge: Digital', 'Opportunity: In-field', 'Opportunity: Digital', or whether other factors are important in driving the identified themes to describe the fieldwork practice.[3]
	Fieldwork practitioner survey (closed questions).	Descriptive statistics to determine frequency (%) of Likert responses to a range of statements. - Digital/virtual fieldwork is necessary to the teaching of my subject. - In-person fieldwork is necessary to the teaching of my subject. - Digital/virtual fieldwork is valued by the learners. - In-person fieldwork is valued by the learners A Schreier-Ray-Hare test was undertaken to determine whether participant responses to these Likert statements was affected by overall delivery mode (Digital or In-field) and/or the individual statement.[1] Descriptive statistics to determine frequency of responses to. - Fieldwork experience (Four statements: facilitating digital fieldwork, using technology in field, facilitating local/half/full day field trips, facilitating residential fieldwork). - Purpose of digital fieldwork (Ten statements: wrap-around support, preparation, develop subject specific digital skills, promote efficiencies, provide spatial and temporal considerations, simulate

		scenarios, interpretation of a variety of data sources, increase access and equity to fieldwork, reduce health and safety issues and logistical considerations, other).
	Student focus group.	Ranking of the top five priorities of the defining characteristics from each student focus group where a priority of one has been given a score of five, a ranking of two has been given a score of four, a ranking of three has been given a score of three, a ranking of four has been given a score of two and a ranking of five has been given a score of one. These top five priorities were grouped inductively into themes, with total rank score for each of these themes calculated.

[1] This statistical analysis was undertaken using SPSS (IBM SPSS Statistics for Windows, version 29.0.1.0 (171) (IBM Corp., Armonk, N.Y., USA).

[2] The reflexive thematic analysis was underpinned by the six-stage analytical guidance (Braun and Clarke, 2019; 2020) where the researcher is actively involved in producing themes from the data. Themes and any sub-themes presented within this research represent what participants have communicated within the research, but I acknowledge the role that the author as researcher and workshop host plays in constructing those themes during the data analysis process.

[3] This statistical analysis was undertaken using PRIMER 7 (PRIMER-E, Plymouth, 192pp. v7: Clarke, KR, Gorley, RN, 2015. PRIMER v7: User Manual/Tutorial. PRIMER-E, Plymouth, 296pp).

2.3 Findings

2.3.1 A taxonomy of fieldwork to define practice post-Covid-19

In reviewing the publication date of each of the 182 articles analysed within the review of the literature and the results of the deductive content analysis it was possible to identify the frequency of fieldwork delivery modes between the years 2000-2023 (Figure 2.3).

Total frequency of delivery modes was higher than 182, with some articles making reference to multiple delivery modes. Overall, there is an increase in the number of journal articles related to fieldwork generally. Between 2000-2008 the mean number of journal articles specifically referencing fieldwork delivery modes was 4 (range = 4), between 2009-2019 the mean number of journal articles increased to 10.7 (range = 13). The relationship between the number of journal articles that contained the different fieldwork delivery modes over time identified a peak number of journal articles in 2020 for all digital delivery modes, with a peak in journal articles for in-field approaches in 2013, which was associated with a low in blended, technology in field and virtual delivery modes (Figure 2.3).

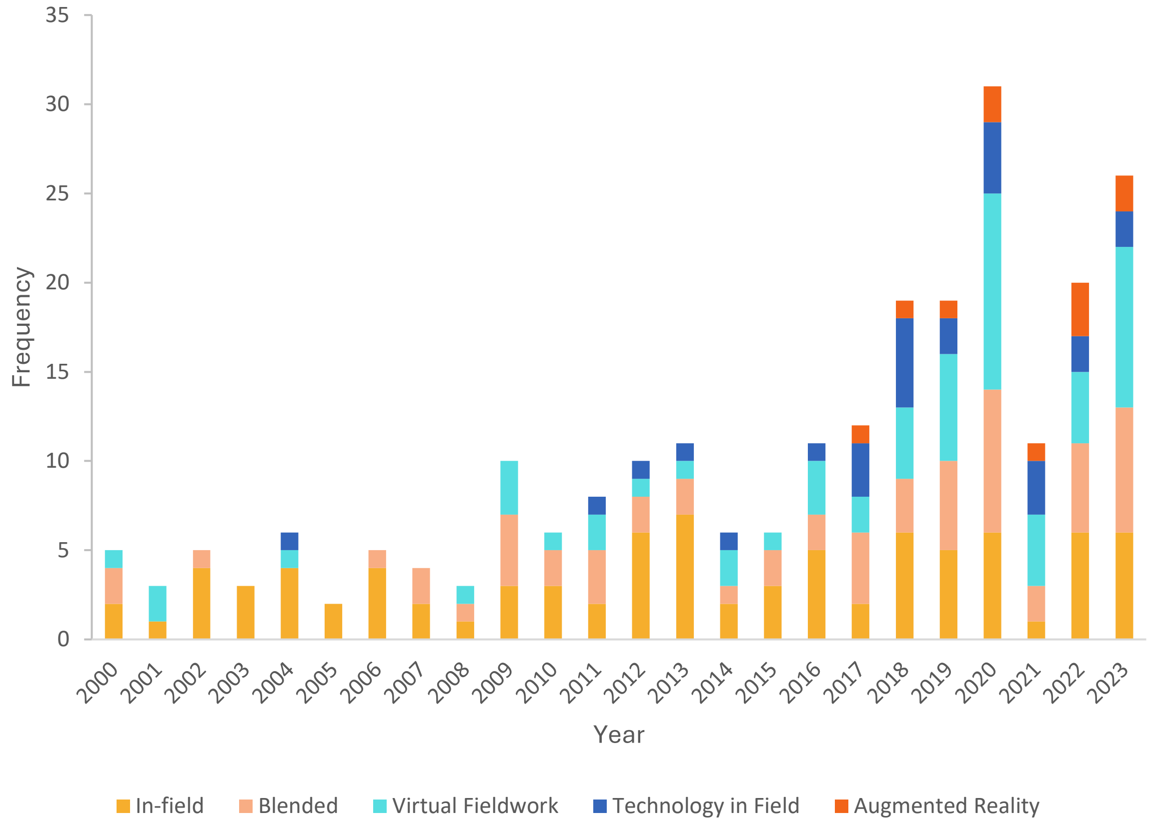

Figure 2.3 Summary of the deductive content analysis showing frequency of fieldwork delivery modes identified within 182 journal articles between the years 2000-2023. Of these, 145 journal articles were identified via a search strategy undertaken in May 2021 (2000-2020) and 37 (2021-2023) identified via a search strategy undertaken in October 2024 on the SCOPUS database. A review of the abstracts was undertaken with abstract mining using inclusion and exclusion criteria to identify papers to review delivery mode within.

A comparative analysis was undertaken on the results of this deductive content analysis to identify if any of the modes of fieldwork (in-field, blended, virtual, technology in field, augmented reality) had grown or declined in their inclusion within journal articles over time. Using these annual data, the comparative analysis was used to compare the correlation between the frequency of journal articles for each fieldwork delivery mode.

In testing for normality using the Shapiro-Wilk test, four of the factors had a significance smaller than $P < .05$ (Blended .008, Virtual <.001, Technology in Field <.00 and Augmented Reality <.001). These violated the assumption of normality, with the data for these four variables not following a normal distribution pattern. Therefore, the Spearman correlation coefficient, which does not assume normality, was applied to these data. A correlation matrix with heatmap (Figure 2.4) summarises the Spearman's correlation co-efficient with the relationships for these data plotted (Figure 2.5).

There was a significant positive correlation between Year and the number of journal articles that focused on Blended (r_s = 0.764), Virtual (r_s = 0.785), Technology in Field (r_s = 0.818) and Augmented Reality fieldwork approaches (r_s = 0.795) (Figure 2.4; 2.5). These were all significant at the P = 0.01 level. Over time there was a statistically significant increase in the number of journal articles with a focus on these particular digital fieldwork approaches (Figure 2.4; 2.5).

There was no statistically significant correlation between the annual number of journal articles focused on in-field approaches with the annual number of journal articles for Virtual and Augmented Reality (Figure 2.4; 2.6), suggesting that within the literature, In-field fieldwork was used independently of these digital fieldwork approaches.

There was a significant positive correlation between the annual number of journal articles focused on Augmented Reality and the annual number of journal articles focused on Technology in Field (r_s = 0.813, P < 0.01), between Virtual and Technology in Field (r_s = 0.775, P < 0.01), between Technology in Field and Blended (r_s = 0.634, P < 0.01), between Augmented Reality and Blended (r_s = 0.726, P < 0.01), between Virtual and Augmented Reality (r_s = 0.763, P < 0.01)and between Virtual and Blended (r_s = 0.745, P < 0.01) (Figure 2.4; 2.6), suggesting that digital fieldwork approaches may be used in combination with one another.

	Year	**In-field**	**Blended**	**Virtual**	**Technology in Field**	**Augmented Reality**
Year	1.000					
In-field	0.430	1.000				
Blended	0.764	0.444	1.000			
Virtual	0.785	0.278	0.745	1.000		
Technology in Field	0.818	0.431	0.634	0.775	1.000	
Augmented Reality	0.795	0.360	0.726	0.763	0.813	1.000

-1	-0.9	-0.8	-0.7	-0.6	-0.5	-0.4	-0.3	-0.2	-0.1	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1

Figure 2.4 Spearman's correlation co-efficient matrix with applied heatmap showing the strength of correlation and whether this correlation was positive or negative between each individual factor.

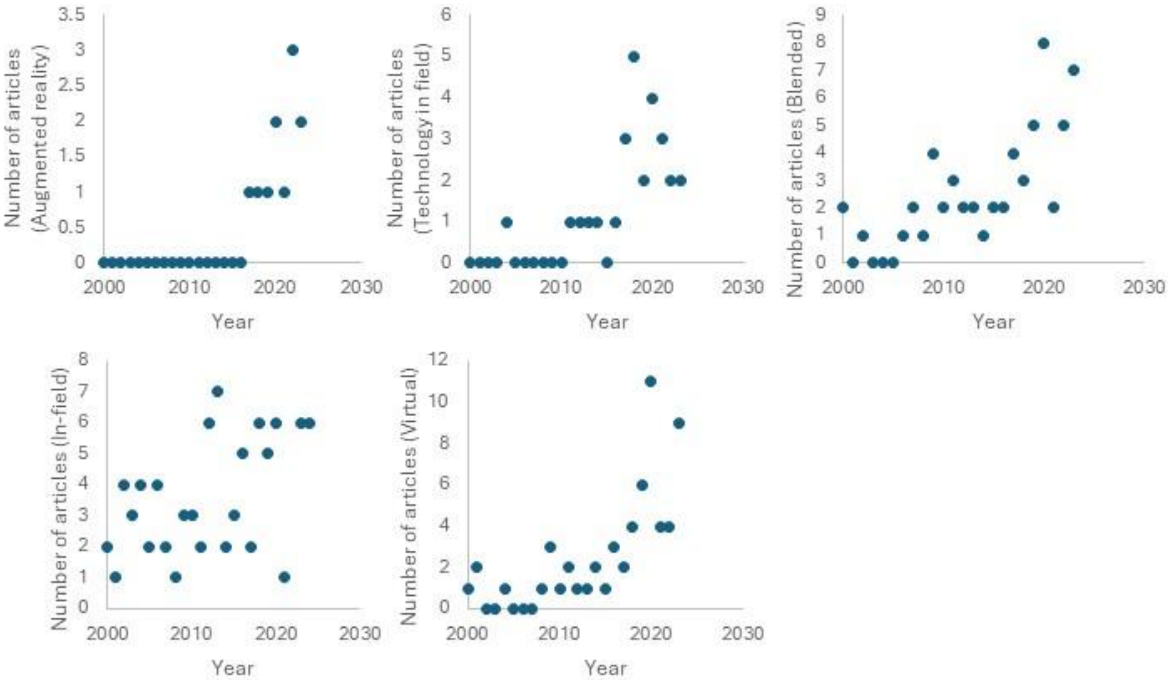

Figure 2.5 Relationship between the number of journal articles per fieldwork delivery mode and year.

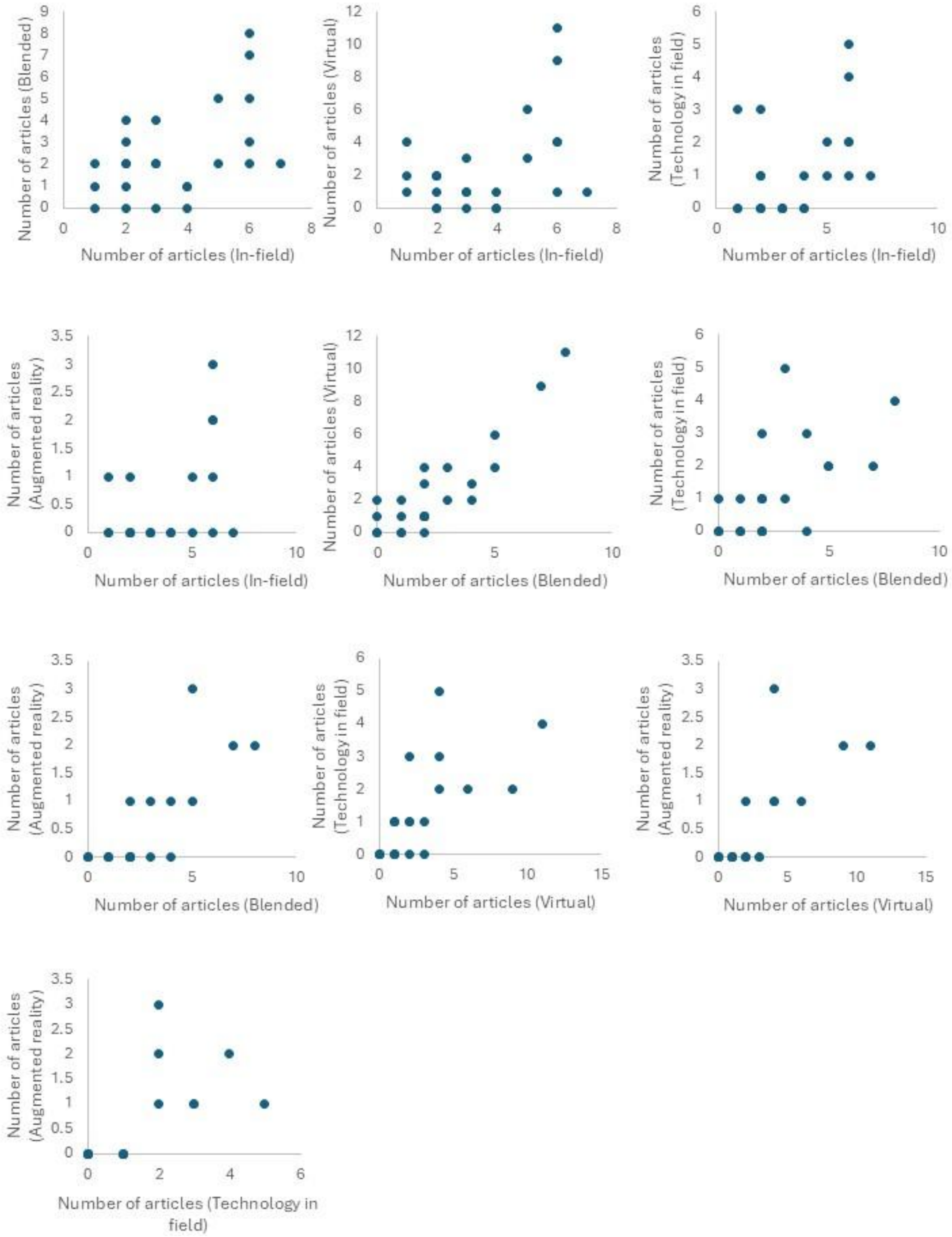

Figure 2.6 The relationship between the annual number of journal articles published on each fieldwork delivery mode (in-field, blended, virtual, technology in field and augmented reality). Each point on the graph represents the number of journal articles referencing a particular fieldwork delivery mode in a single year from 2000 to 2023.

A diverse list of fieldwork activities was identified within the literature and shared by participants within the expert panel interviews and fieldwork practitioner survey. In reviewing this list and evaluating the underlying pedagogic approach and delivery mechanisms used to deliver the fieldwork, a summary of fieldwork post-Covid-19 was constructed (Figure 2.7).

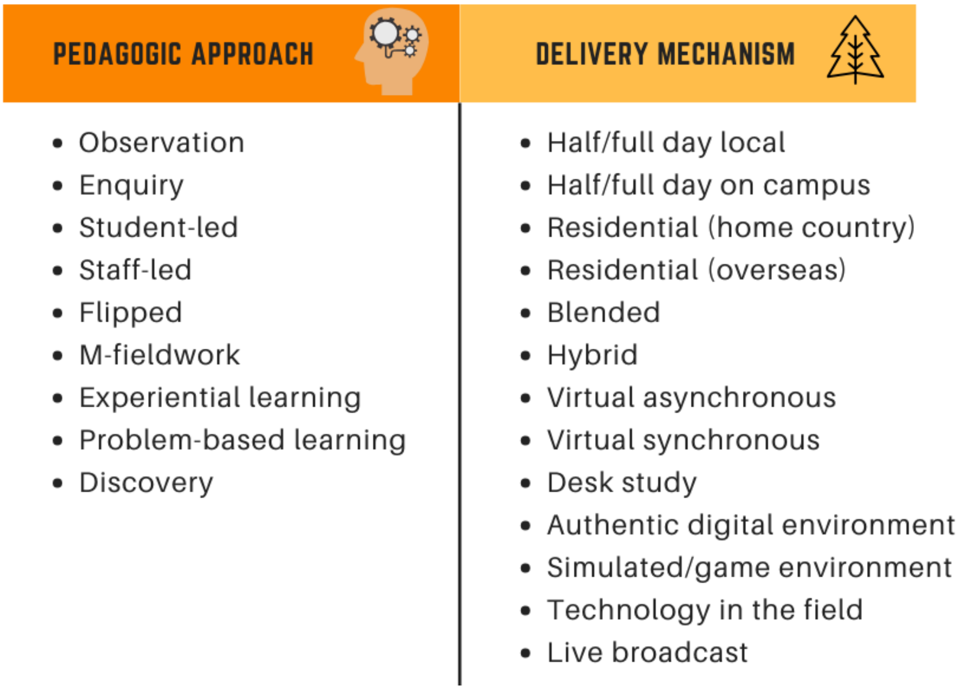

Figure 2.7 Taxonomy of fieldwork post-Covid-19. Using the pedagogic approach and delivery mechanism to describe the broadened practice within fieldwork described by participants within expert panel interviews, fieldwork practitioner survey and identified within the literature (2000-2023).

This taxonomy of fieldwork can be used as a tool to define current fieldwork practice and can be applied to descriptions of fieldwork from the expert panel interviews and fieldwork practitioner survey (Table 2.6).

Table 2.6 Using the taxonomy of fieldwork post-Covid-19 to define fieldwork practice identified within the expert panel interviews and fieldwork practitioner survey.

Description of fieldwork	**Defining the fieldwork**
"…you can gain a lot from just looking at old maps and the old aerial imagery to see how it's (a landscape is) formed over time." (EXP A)	Learner-led fieldwork enquiry using desk-study resources.
"You can put an app on your phone you know the Google lens and that stuff where you can actually look around in 3D." (EXP I)	M-fieldwork using technology in the field.
"VR project recreating…hazardous environments. Students have been able to undertake 'fieldwork' in areas of the world they cannot reach." (Fieldwork practitioner survey F14)	Observation in a virtual synchronous authentic environment.

The results of the inductive content analysis from the review of the literature (conducted only on the May 2021 review for articles published in 2000-2020 as it informed subsequent development of digital tools) identified six themes to describe the defining characteristics of digital fieldwork. These were: active participation, useability, access and equity, preparation, collaboration and enhancement of experience. The frequency of occurrence of each of these themes from the literature is summarised by the overall digital delivery mechanism (Blended, Technology in Field and Virtual) (Figure 2.8). Despite the digital mechanism of delivery, active participation was the highest frequency defining characteristic of digital fieldwork, with it being described within 37 of the 145 journal articles. The usability of the digital fieldwork approach was another high frequency defining characteristic from the literature, with it being described within 29 of the 145 journal articles. Within the literature, access and equity was a defining characteristic of the digital fieldwork approach within 28 journal articles. Seventeen of these were identified from a virtual fieldwork delivery mechanism, this shows the potential for virtual fieldwork to help support access and equity issues within fieldwork. The role of digital fieldwork to prepare learners for fieldwork was identified as a defining characteristic in 28 journal articles. Interestingly just over half of these were described within a fully blended approach to fieldwork (15 out of 28 articles) which supported flexible learning across different modalities which learners can access at their own pace, while 13 out of 28 articles described the role of virtual fieldwork approaches to prepare for in-field fieldwork practice. The role of digital fieldwork to support collaboration was identified within 27 journal articles across blended, virtual and technology in field delivery mechanisms. This digital collaboration was identified as being between peers, between facilitators and learners and between learners and remote experts through the use of both synchronous and asynchronous communication tools.

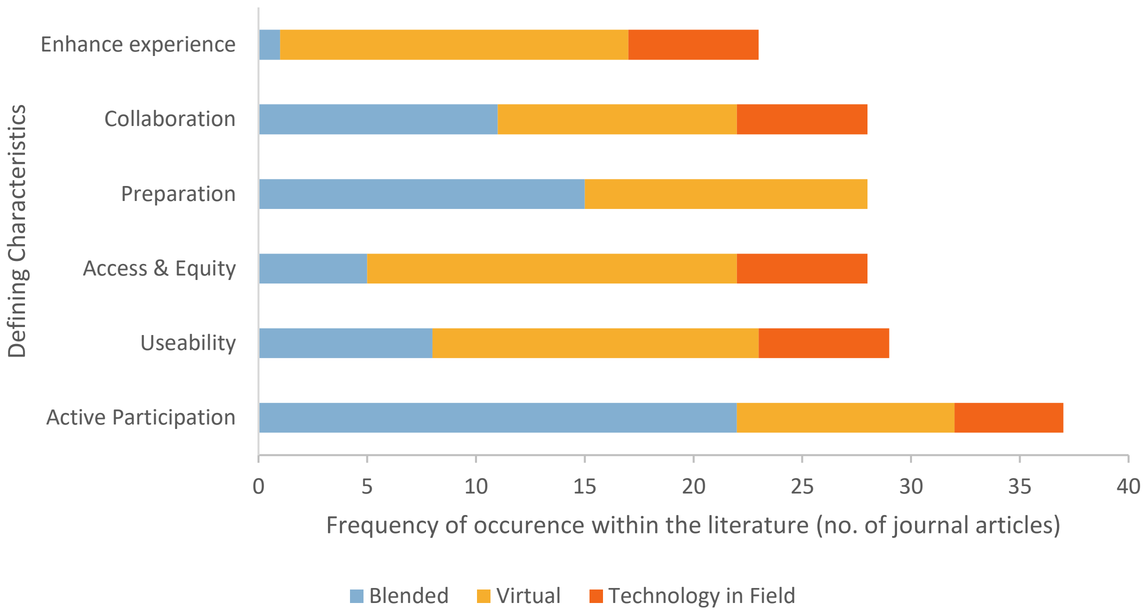

Figure 2.8 Frequency of the defining characteristics of digital fieldwork identified from inductive content analysis of the 145 journal articles identified from the review of the literature (2000-2020). The frequency of occurrence of each of these defining characteristics is summarised by the overall digital fieldwork mechanism (Blended, Virtual and Technology in Field).

2.3.2 Student priorities on characteristics of digital fieldwork

Within the student focus groups, participants were asked to share their views on the defining characteristics of digital fieldwork, with them working within the focus-group to prioritise these characteristics. Table 2.7 summarises the top five student priorities of the defining characteristic from each of the four focus groups with Table 2.8 summarising ranked themes of defining characteristics of digital fieldwork across all student focus groups. Table 2.9 provides student quotes to illustrate these themes.

Table 2.7 Top five priorities identified from student focus groups on the defining characteristics of digital fieldwork. Each characteristic was categorised within a summary theme.

Priority	Focus group 1 (n = 5)	Focus group 2 (n = 8)	Focus group 3 (n = 3)	Focus group 4 (n = 6)
1	Immersive and interactive.	Accessibility to increase access to fieldwork opportunities.	In-depth videos to explore what would happen on fieldwork.	Digital at point of capture, efficient cloud saving, GIS.
2	Having lecturer present for questions, motivation and guidance.	Explore different environments.	Relating back to previous years, previous data and results.	Easy to use/already know how to use; intuitive user experience.
3	Pictures, videos, 360° images and equipment lists.	More tools and software use; digital skill development.	Short videos to introduce sites, to be better prepared.	Access to real-time data.
4	Used in conjunction with some practical activities.	Emulate in-person fieldwork as much as possible.	Walk through of sites.	Technical difficulties considered (internet, battery, waterproofness).
5	Demonstrative videos.	Repeatable, can look back over.	Immersion.	Portable, centralized, everyone can access.

Summary themes

Feeling of immersion	Practical	Preparation	Access and equity	Digital skills	Technical consideration	Synchronous

Table 2.8 Ranked themes of defining characteristics of digital fieldwork across all student focus groups. Ranking was conducted from Table 2.7 where a priority of one was given a score of five, a ranking of two was given a score of four, a ranking of three was given a score of three, a ranking of four was given a score of two and a ranking of five was given a score of one.

Rank	Identified Theme	Rank Score
1.	Digital skills.	15.
2.	Feeling of immersion.	12.
3.	Access and equity.	11.
4.	Preparation.	9.
5.	Technical consideration.	6.
=6.	Synchronous.	4.
=6.	Practical.	4.

Despite digital skills being identified as a top priority in only one out of the four focus groups, based on rank score, the development of digital skills was identified as a top priority within the student focus groups (Table 2.8). Students commented on the authentic opportunities to develop specific digital skills such as GIS (Geographical Information Systems) or spatial temporal modelling that enhanced the overall fieldwork experience and would be difficult to achieve in traditional in-field fieldwork. One student commented on the role of modelling to extend the reach of the research beyond the data collected at that time (Table 2.7; 2.9). Specific examples of digital tools that could be used to develop these skills and how they could be used in the field were also mentioned (Table 2.7; 2.9). Students had high expectations of the digital fieldwork and its sense of realness. Students want digital fieldwork to engage them and provide a feeling of immersion in the fieldwork landscape virtually (Table 2.7; 2.9). Access and equity were one of the top priorities for the defining characteristics of digital fieldwork, with students sharing personal accounts of the opportunity of digital fieldwork approaches to address specific access issues in fieldwork (Table 2.7; 2.9). This highlights the potential role of a digital delivery mode for fieldwork offering an equitable method to deliver the equivalent fieldwork skills. Another specific access issue discussed was cost, and the role of digital fieldwork to offer potential solutions to address this. For some fieldwork locations, digital fieldwork could open access to these locations for students who would be excluded from participating due to the cost implications associated with these locations (Table 2.7; 2.9). Preparation for fieldwork was another top-ranking defining characteristic of digital fieldwork with participants sharing how they could use digital preparation resources to build knowledge, skills, and confidence prior to embarking on in-field fieldwork (Table 2.7; 2.9). Specific examples of content within this digital preparation for fieldwork were shared, with students commenting on how this would benefit their subsequent in-field fieldwork experiences (Table 2.7; 2.9). Unsurprisingly technical considerations were identified as a key defining characteristics for digital fieldwork. With students sharing that digital fieldwork tools that they can use without spending time acquiring the digital skills and technology knowledge to use the resource were preferred (Table 2.7; 2.9). Within the focus groups, students also rejected a passive role within digital fieldwork. Students shared their desire for digital fieldwork approaches to emulate the hands-on active learning associated with in-field fieldwork (Table 2.7; 2.9). Specific examples of practical activities to increase engagement and support active learning in a digital fieldwork environment were shared (Table 2.7; 2.9). This desire for active participation with digital fieldwork was also supplemented by the defining characteristics related to synchronous delivery of the digital fieldwork resources and the role of a facilitator to support motivation and engagement for the students (Table 2.7; 2.9).

Table 2.9 Quotes captured during student focus groups illustrating the identified themes of defining characteristics of digital fieldwork.

Theme	Student quote captured during focus groups
Digital skills.	*"If you were using modelling and data analysis…you could use the data that you have got (collected) and forecast for the future as well." S8*
	"Working off a pro-form on ArcGIS or Collector or something…we could have put on the exclusion zones for the ospreys." S17
Feeling of immersion.	*"So, you want to feel like you're there, instead of you know looking at your laptop screen." S4*
Access and equity.	*"…a big one is accessibility which is quite a close one to me. Because well, I've developed chronic illness in third year and wasn't able to do my fieldwork module. Which they then switched me to another theoretical module instead, which is fine. But still being able to gain fieldwork experience without having to like go would be good." S6*
	"It may allow students to visit localities they couldn't otherwise visit...during my degree, our university…there was one field trip and it was possible to go abroad to Central America for that trip. There was lots of different trips, but anything that involved going overseas you had to pay for. And you had to pay transport, quite a lot of transport (costs) to go to Costa Rica. Anything that makes tropical rainforest accessible for fieldwork in the UK is probably quite a good thing." S10
Preparation.	*"Better prepared. Like help you decide, what project or area of focus to do…so you already know before you get there what different things are. And like you have like a base knowledge of how to use them." S15*
	"The virtual one with the 360° views, I think it was a lot easier to kind of see the difference in zonation because I could just revisit the sites, whenever I wanted and look at whatever I wanted…So actually if you could use them in conjunction, I actually think that would be the best of both worlds. You get the most out of it if maybe you could like look online first, see what you want, make a plan and then go outside." S3

Technical considerations.	*"I didn't think there is any point in having to use something where you've got to learn new language, or you know spend a lot of time doing research where you have to put in lots of learning time to use the stuff you are going to be using…" S21*
Practical.	*"They need to be engaging because like (S3) said, like not many people have three-hour long attention span for just staring at a laptop. Whereas attention span in the field obviously is longer…it needs to be interactive." S4*
	"When we say digital fieldwork, I immediately thought of Citizen Science apps and things like that… actually like a hybrid because it's obviously in-person data collection from everyone but in a way it's all reliant on this app that everyone has and so it's digital." S8
Synchronous.	*"Always have a lecture present like either if you're doing it in a room, or if it's like online, you can talk to them, ask questions. And they can keep you, guided because, if it was just me just online, I'm not sure how long my attention would last." S3*

2.3.3 Practitioners' perspectives on the value of digital fieldwork

Fifty-seven survey responses were received from practitioners: 24 recipients defined their job role as a Fieldwork Practitioner, 15 as a Teacher (School & College), eight as a Higher Education Lecturer, and four as Education Support within Higher Education. Five survey responses described their job role as 'Other' with job roles described as a combination of the existing categories, Education Officers or as Fieldwork Specialists for Awarding Organisations.

Within the fieldwork practitioners survey, practitioners were asked whether they were in support of adopting digital or virtual fieldwork to enhance existing fieldwork provision. Two-thirds (67%) were in agreement with adoption of the digital tools in fieldwork with one-third either unsure (23%) or against (10%) this adoption.

The 'necessity' and 'value' of in-field and digital fieldwork was assessed using practitioners' views of four statements using a Likert scale *('1. Strongly disagree', '2. Disagree', '3. Neutral', '4. Agree', '5. Strongly agree')* (Figure 2.9).

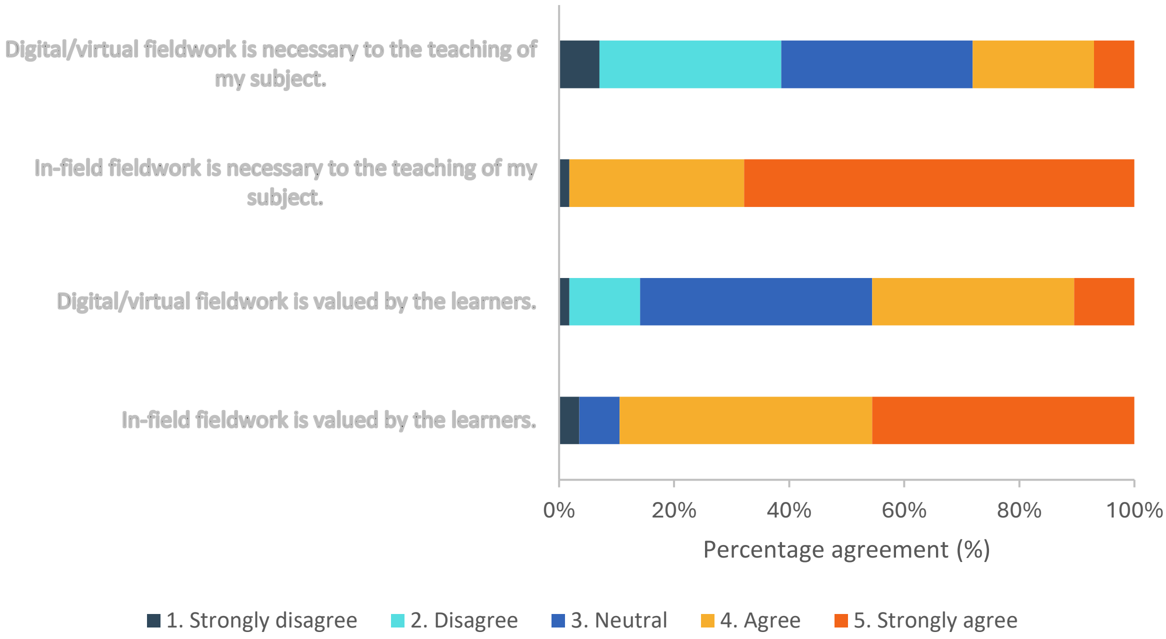

Figure 2.9 Percentage agreement on four statements about in-field and digital fieldwork using a five-point Likert assessment (n = 56).

Practitioners agreed with the necessity of in-person fieldwork to the teaching of their subject with 98% of participants either agreeing or strongly agreeing with the statement*; 'In-field fieldwork is necessary to the teaching of my subject.'* When compared to the necessity of digital fieldwork to the teaching of their subject the results were more mixed, with 28% agreeing or strongly agreeing, 39% disagreeing or strongly disagreeing and 33% remaining neutral to the statement; *'Digital/virtual fieldwork is necessary to the teaching of my subject.'*

Practitioners were also asked for their perceptions on how learners value in-field and digital fieldwork. Again in-field fieldwork was seen to be viewed favourably by learners with 91% of practitioners agreeing or strongly agreeing with the statement; *'In-field fieldwork is valued by the learner'* (Figure 2.9).

But when compared to the practitioners' perception on how learners value digital fieldwork the view was again mixed, with 45% agreeing or strongly agreeing, 40% neutral and 14% disagreeing or strongly disagreeing with the statement; *'Digital/virtual fieldwork is valued by the learner'* (Figure 2.9).

In grouping these statements into the 'Delivery Modes' (Digital and In-field) a Schreier-Ray-Hare test showed that participant response was affected by the interaction between the two factors (χ^2 Interaction = 7.33, $P < 0.001$). Participant response was affected by the overall delivery mode (χ^2 Delivery Mode = 87.72, $P < 0.001$) but not by the individual statement (χ^2 Individual Statement = 0.00004, $P < 0.001$).

Some of this can perhaps be explained by practitioners' experience of digital fieldwork approaches (Figure 2.10), where 27% of participants did not have experience of facilitating digital fieldwork and 19% did not have experience of using technology in fieldwork.

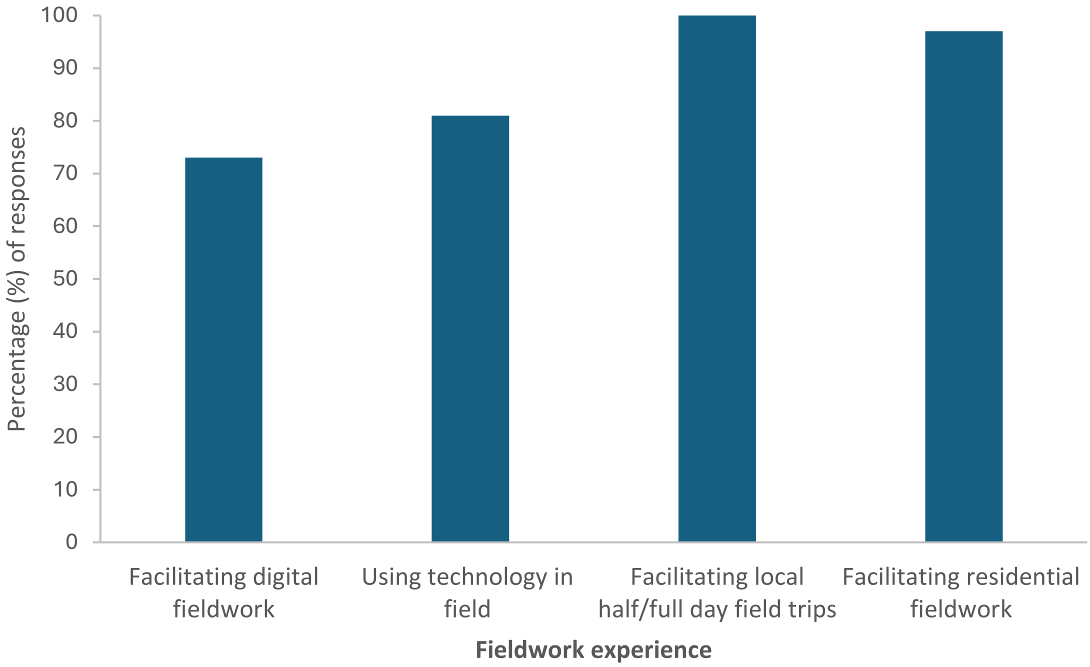

Figure 2.10 Fieldwork experience of the respondents of the fieldwork practitioner survey (n = 56).

Based on responses to the open question, *'What is the purpose of digital fieldwork approaches?'* within the expert panel interviews, nine statements that defined the purpose of digital fieldwork were identified. These statements were then presented within the fieldwork practitioner survey, where practitioners were asked *'What do you think is the purpose of digital or virtual fieldwork?'* Figure 2.11 summarises responses, with participants selecting all the statements that they agreed with.

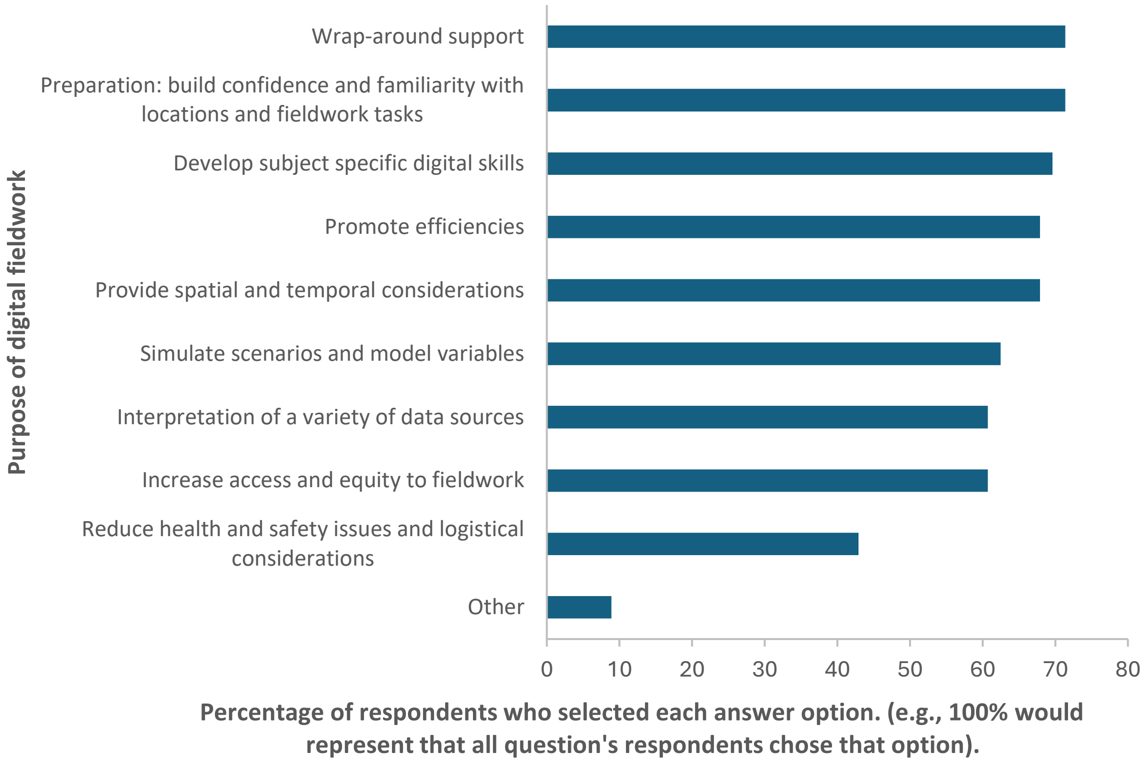

Figure 2.11 Participant responses to the question 'What do you think is the purpose of digital or virtual fieldwork?' within the fieldwork practitioner survey (n = 56). Options presented reflect outcomes of the expert panel interviews; 100% would represent that all of the respondents to the question chose that option.

There were five individual responses (8.9%) who selected 'Other' for the purpose of digital fieldwork, which showed how comprehensive the purposes derived from the expert panel interviews were. Practitioners provided their specific purpose when selecting this option.

Two responses focused on the affordance of digital fieldwork to do what cannot be done during in-field fieldwork, a single enhanced view of how digital fieldwork could prepare learners, and two responses presented a negative view of digital fieldwork and did not identify a purpose of the approach (Table 2.10).

Table 2.10 Participant responses who selected 'Other' for the purpose of digital fieldwork. These are grouped into three themes.

Themes	Participant quote
Affordance of digital fieldwork.	*"Enables the impossible to do in real world contexts/environments.'*
	"Can provide an important overview of a landscape (such as hard to reach mountain tops etc.) so that students get an appreciation of what it is like beyond what they can see in valleys etc and how it fits together." Fieldwork practitioner survey F35
Enhanced view.	*"Preparation: risk management and awareness." Fieldwork practitioner F50*
Negative view.	*"It has become a lazy option for teachers who don't want to get wet in the rain. It is not primary data collection and might as well be a case study of secondary information." Fieldwork practitioner survey F6*
	"Covid-meant this was the only option." Fieldwork practitioner survey F17

2.3.4 Challenges and opportunities of fieldwork and digital fieldwork

Within the expert panel interviews and fieldwork practitioner survey, participants were asked to share the challenges and opportunities of both in-field and digital fieldwork. Inductive content analysis of these statements enabled the frequency of challenges and opportunities for both approaches to be identified (Table 2.11). This inductive content analysis was conducted by the author, but with codes discussed and defined with the supervisory team prior to completing the content analysis to ensure consistency for identifying the codes in the data. In total 65 codes were identified within the data, which were summarised based on 'Challenge' or 'Opportunity' and 'In-field' or 'Digital' fieldwork.

Table 2.11 Frequency of challenges and opportunity statements identified across in-field and digital fieldwork delivery modes within expert panel interviews and fieldwork practitioner surveys.

	In-Field Fieldwork	**Digital Fieldwork**	**Total**
Challenge.	151	114	**265**
Opportunity.	131	88	**219**
Total.	**282**	**202**	**484**

Fifty-eight percent of the statements related to in-field fieldwork, and 42% to digital fieldwork approaches, again highlighting participants stronger familiarity with in-field fieldwork approaches. Across both delivery modes participants were also more likely to share challenges experienced (55%) rather than opportunities (45%) (Table 2.11).

However, despite the overwhelming positive views of in-field fieldwork and the mixed views of digital fieldwork from the Likert statements within the fieldwork practitioner survey (Figure 2.8), the open questions presented a roughly even frequency of statements on the challenges and opportunities of in-field and digital fieldwork. Challenges: In-field: 54%; Digital: 56%. Opportunity: In-field: 46%; Digital: 44%. Highlighting that practitioners identify challenges and opportunities for enhancement and future development within both in-field and digital fieldwork approaches (Table 2.11).

The results of inductive content analysis of these challenges and opportunities are summarised in Table 2.12, which shares the highest frequency (top five) challenges and opportunities identified across both delivery modes of fieldwork.

Table 2.12 The top five highest frequency themes identified from inductive content analysis of participants' responses within expert panel interviews (n = 10) and fieldwork practitioner surveys (n = 56) to challenges and opportunities of in-field and digital fieldwork.

	In-field Fieldwork			Digital Fieldwork		
Challenges.	**Rank**	**Themes**	**Freq.**	**Rank**	**Themes**	**Freq.**
	1	Novel experience.	22	1	Access to equipment.	18
	2	Time.	18	2	Preparation for learners to use digital resources.	15
	3	Cost.	9	3	Digital poverty.	13
	=4	Pace & Progress.	8	4	Differentiation & personalised support.	8
	=4	Peer-peer communication.	8	=5	Interactive opportunities.	7
	=5	Weather.	7	=5	Cost.	7
	=5	Value realised.	7	=5	Values realised.	7
Opportunities.	**Rank**	**Themes**	**Freq.**	**Rank**	**Themes**	**Freq.**
	1	Synoptic real-world learning.	18	1	Blended.	20
	2	Increased teaching & learning outdoors.	9	2	Spatial & temporal modelling.	13
	=3	Wayfinding & personal connection to location.	8	3	GIS.	7
	=3	Wellbeing & nature connection.	8	4	Affordability & efficiencies.	5
	=4	Free & local spaces.	7	5	Outsourced.	4
	=4	Location.	7			
	=4	Technology in field.	7			
	=4	Peer-peer communication.	7			
	5	Be decision-makers.	6			

A Principal Component Analysis (PCA) was undertaken on the results of the inductive content analysis (Table 2.12) to determine which of the themes identified could be attributed to the driving forces of ‘Challenge: In-field’, ‘Challenge: Digital’, ‘Opportunity: In-field’, ‘Opportunity:

Digital', or whether other factors are important in driving the identified themes to describe the fieldwork practice. The PCA revealed the presence of three components with Eigenvalues exceeding 1, which accounted for 100% of total variance (Table 2.13). The PCA plot (Figure 2.12) showed that both in-field opportunities and digital opportunities drove the themes identified, showing that there was no overlap in opportunities identified between digital and in-field approaches. Additionally, in-field challenges and digital challenges did drive the themes identified, but there was some overlap in themes between digital and in-field approaches.

Table 2.13 Principal Component Analysis (PCA) values identifying three principal components of the themes identified to describe the challenges and opportunities of in-field and digital fieldwork.

Principle component	**Eigenvalue**	**% Variation**	**Cumulative % Variation**
1.	317	37.7	37.7
2.	288	34.3	72.0
3.	235	28.0	100.0

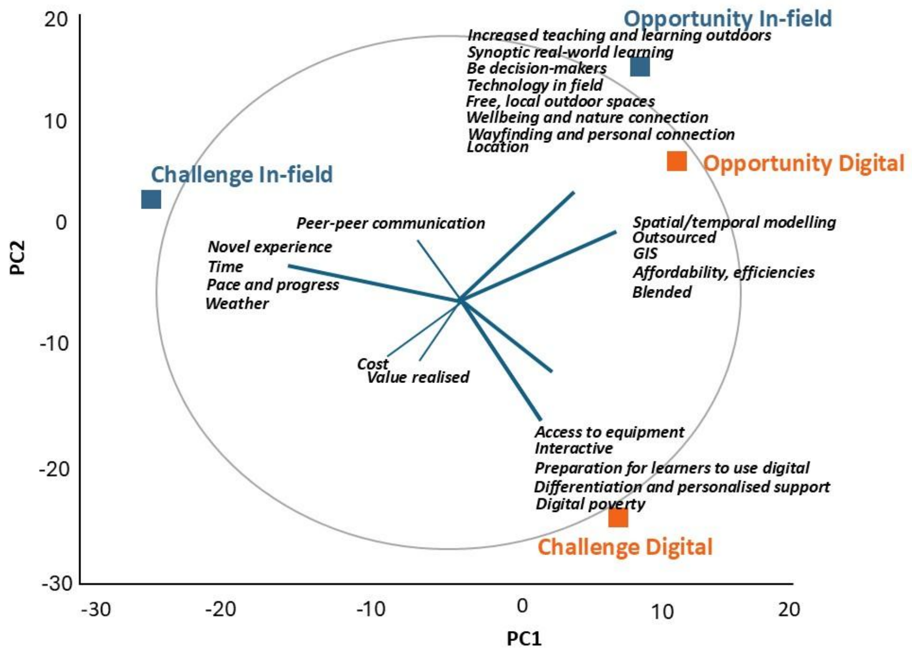

Figure 2.12 Principal Component Analysis (PCA) plot to show which of the identified themes can be attributed to: 'Challenge: In-field', 'Challenge: Digital', 'Opportunity: In-field', 'Opportunity: Digital'.

Additionally, these same statements made by participants on the challenges and opportunities of both in-field fieldwork and digital fieldwork were also analysed using reflexive thematic analysis which support the understanding of how practitioners view each approach. Figure 2.13 provides a visual thematic map representing the themes identified from the reflexive thematic analysis.

Firstly, the collaboration between in-field and digital fieldwork was identified with a blended approach and the use of technology in field identified; along with the use of GIS and modelling. Logistics was an identified theme with considerations of cost, weather, equipment, time, digital poverty and efficiencies shared. There were several identified sub-themes related to the learners' zone of development during fieldwork. These included the novelty of the fieldwork environment, the preparation needed to use digital tools in fieldwork, the requirement of differentiation to modify the instruction or tool to meet the needs of individual learners and monitoring the pace and progress of the fieldwork learning activity. Additionally, the role of the learner during fieldwork was identified with roles including decision-making, interactive opportunities, and peer-peer communication. Fieldwork is inherently place-based and there were several sub-themes identified within the reflexive thematic analysis related to this; real-word, local, location, increased time outdoors, way-finding, and personal connection and wellbeing and nature connection. Finally, it was identified that there is a need to realise the value of a fieldwork approach.

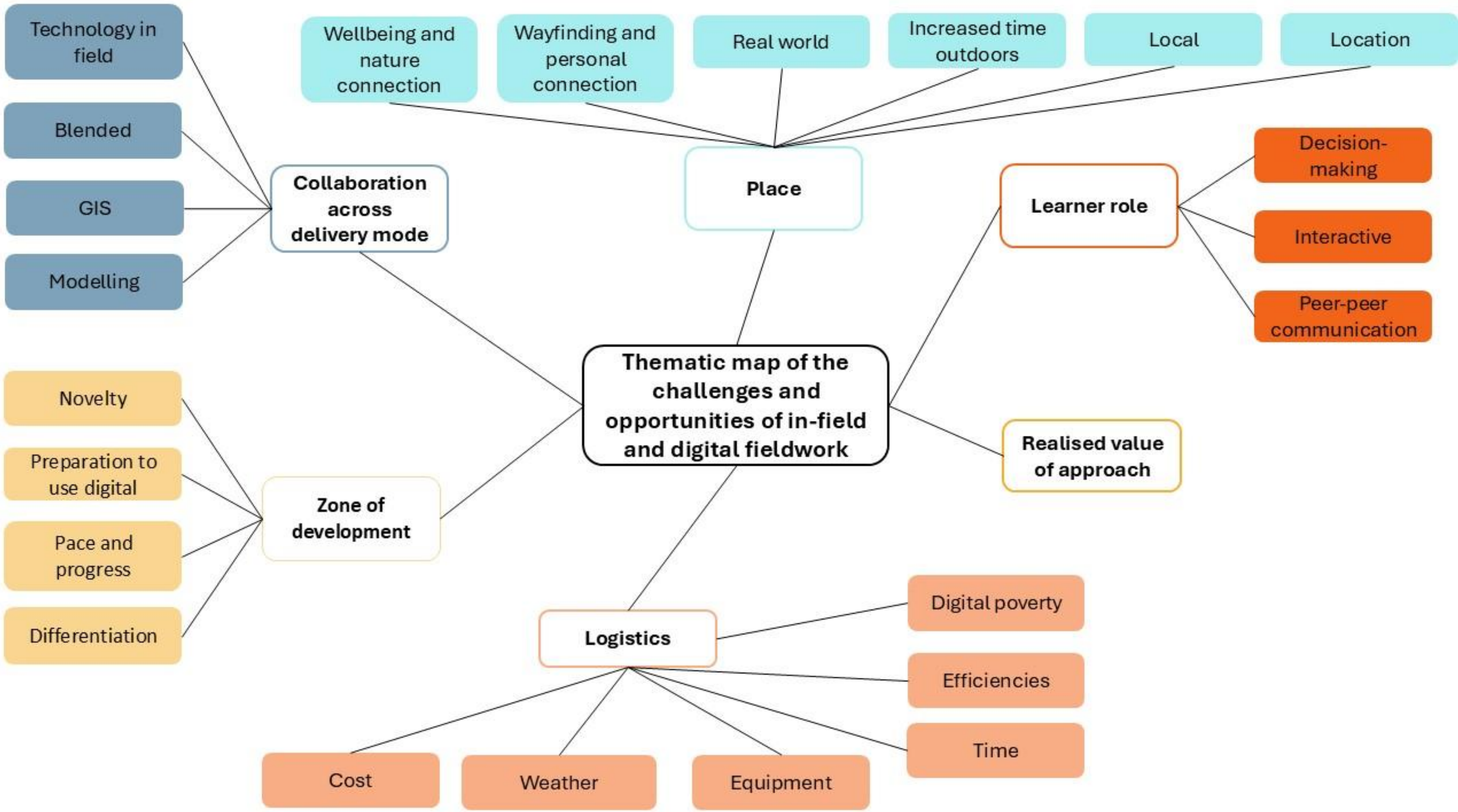

Figure 2.13 Thematic map to illustrate the identified themes of the reflexive thematic analysis of practitioners' responses to the challenges and opportunities of in-field and digital fieldwork.

In reflecting upon the PCA (Figure 2.12), the thematic map arising from the reflexive thematic analysis (Figure 2.13) and reviewing where there was overlap across delivery mode, a summary of the challenges and opportunities of in-field and digital fieldwork identified within this research was constructed (Figure 2.14).

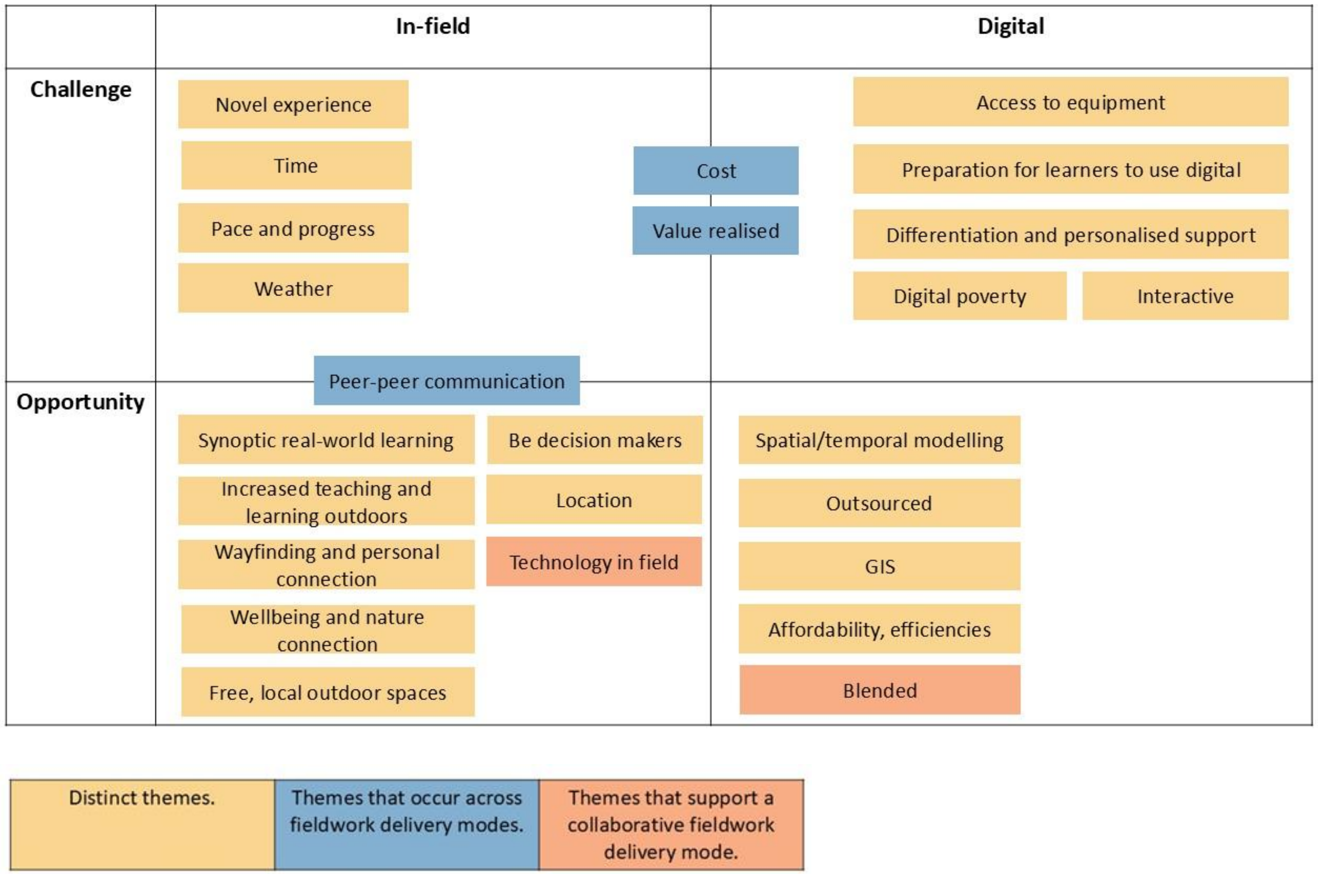

Figure 2.14 Challenges and opportunities of in-field and digital fieldwork identified from content analysis of responses from expert panel interviews (n = 10) and fieldwork practitioner surveys (n = 56). Colour coding of the themes refer to distinct themes identified (yellow), themes that occur across from in-field and digital fieldwork delivery modes (blue) and themes which support a collaborative fieldwork delivery mode (orange).

Practitioners identified that the novelty of the fieldwork environment, pace and progress, time and weather posed distinct challenges within in-field fieldwork. These were different from the distinct challenges of a digital fieldwork environment which included access to equipment, preparation for learners to use digital resources, digital poverty, differentiation and personalised support and interactive opportunities. Quotes shared by participants from the fieldwork practitioner survey and expert panel interviews exemplify some of these identified themes for the challenges (Table 2.14).

Providing differentiation and personalised support during digital fieldwork was identified as challenging. Participants commented on the digital delivery mode creating a barrier between the learner and themselves, meaning it was more challenging to engage with individual learners. Participants reflected upon this challenge experienced during their own digital fieldwork teaching (Table 2.14). Although it was shared that assessment was undertaken during digital fieldwork, practitioners found it harder to act upon feedback from the assessment, reducing the effectiveness of the formative assessment task due to the rigid nature of the digital tools limiting this (Table 2.14). A lack of opportunity to interact with the physical environment impacting upon learners' ability to engage with the fieldwork task (Table 2.14). Practitioners identified that learners needed preparation prior to using digital fieldwork as the learning tasks were unfamiliar and students lacked the digital skills required to utilise the digital fieldwork opportunities effectively (Table 2.14). One participant commented on the perception vs. reality of learners' ability to use digital tools (Table 2.14). Appropriate access to the equipment needed to support digital fieldwork both institutionally and on an individual basis was identified as a challenge. Practitioners recognised that digital poverty could undermine the aims of digital fieldwork and limit its capabilities (Table 2.14).

There were some challenges that spanned delivery modes of fieldwork. Cost was a challenge both for digital and in-field fieldwork (Table 2.14). The ability for learners and practitioners to value the fieldwork was identified as challenge for both in-field and digital modes of delivery, with limitations of fieldwork shared, and how this can influence the realised value of digital fieldwork (Table 2.14).

Survey results identified opportunities that digital fieldwork provided, these were all distinct to the delivery mode. These opportunities present unique affordances of the delivery mode. Quotes shared by participants from the fieldwork practitioner survey and expert panel interview exemplify some of these identified themes for the opportunities (Table 2.15).

Practitioners, like students, identified digital skills such as GIS that could be developed during digital fieldwork, with some of the same specific tools mentioned (Table 2.15). Like students in the student focus groups, practitioners identified that spatial temporal modelling was an opportunity afforded by digital fieldwork. Practitioners unlike students, however, were able to provide detail on how this could be embedded within fieldwork through viewing contrasting fieldwork environments and in illustrating processes or features that cannot be seen in one location and one time (Table 2.15). Although cost was a challenge identified across both delivery modes, practitioners did identify that digital fieldwork could provide affordability and efficiencies within fieldwork. Efficiency savings related to carbon was specifically mentioned with the sustainability of digital fieldwork discussed (Table 2.15). Like students, practitioners identified the opportunity of digital fieldwork to prepare for in-field fieldwork and support the development of fieldwork skills (Table 2.15). Practitioners highlighted however that this more blended approach provided multiple engagements and the benefits that this could provide (Table 2.15). The main driver for the development of digital tools in fieldwork could come from an understanding of the in-field challenges (top left Figure 2.14) and consideration of how to utilise the opportunities afforded by digital fieldwork (bottom right Figure 2.14). Understanding these factors helps align digital fieldwork development with user needs, ensuring that technological advancements enhance the fieldwork experience.

Table 2.14 Participant quotes from the fieldwork practitioner survey and expert panel interviews to illustrate the identified themes associated with the challenges of in-field and digital fieldwork.

Theme	Practitioner quotes
Differentiation and personalised support.	*"It's harder to engage directly with the students during virtual fieldwork and so there isn't as much differentiation because it's hard to gauge how they're getting on." Fieldwork practitioner survey F28*
	"Reduced ability to dynamically change a task based on AfL (Assessment for Learning)." Fieldwork practitioner survey F31
Interactive.	*"Retaining motivation without the stimulation of all the sensory experience of an in-person field experience." Fieldwork practitioner survey F36*
Preparation for learners to use digital.	*"Unfamiliarity with digital tasks." Fieldwork practitioner survey F41*
	"Many students lack basic ICT (Information and Communication Technology) skills and this means that simple GIS tasks activities take a long time to complete." Fieldwork practitioner survey F5
	"Students are not the digital natives we believe them to be. This influences their approaches to this form of learning." Fieldwork practitioner survey F1
Digital poverty.	*"If virtual fieldwork is intended to be immersive and replicate some aspects of the field experience (and much virtual fieldwork does seek to do this), then the experience is undermined if the devices used to view the resources are small and/or old and/or have poor internet connectivity." Fieldwork practitioner survey F32*
Cost.	*"I would like to be able to use apps to design and record work but we don't have the technology and our students can't afford £5 for an app." Fieldwork practitioner survey F19*
	"…accessing funds for accommodation, transport or equipment can be difficult…" Fieldwork practitioner survey F38
Value realised.	*"Students can only observe, rather than do." Fieldwork practitioner survey F46*
	"It can be dull compared to experiencing the real thing." Fieldwork practitioner survey F23
	"There needs to be a clear structure of learning objectives -shared with student prior to the event and revisited in a debrief session afterwards. The

	trip should also clearly relate to these objectives. Otherwise, it is easy for students to not see the point of a trip and even to only attend if it is tied to an assessment." Fieldwork practitioner survey F51

Table 2.15 Participant quotes from the fieldwork practitioner survey and expert panel interviews to illustrate the identified themes associated with the opportunities of in-field and digital fieldwork.

Theme	Practitioner quotes
GIS.	*"GIS - Survey 123, Map viewer, StoryMaps to deliver virtual fieldwork." Fieldwork practitioner survey F5*
Spatial, temporal modelling.	*"Using virtual fieldwork to show contrasting places in the UK. If doing certain fieldwork in the local area, why not use virtual fieldwork to look at a contrasting area." Fieldwork practitioner survey F8*
	"… how the same investigation that you've done could be done in a completely different environment. So, you maybe have a video or a kind of link to some digital fieldwork that looks at a different environment or different species…in order to help students see things that you can't show them in one day in one place." Exp B
Affordability, efficiencies.	*"The carbon footprint of digital is much less than going and doing an in field survey. But in terms of climate change it's only a positive really if we can get the data we need using alternative digital techniques" Exp A*
Blended.	*"As a preparation tool and as a wraparound support to embed fieldwork skills…rather than one off experiences." Fieldwork practitioner survey F21*
	"It actually allows multiple engagements so that you can reinforce learning and it becomes a normal a more permanent record." Exp C
	"Wrap around support, building background knowledge before a fieldwork experience and afterwards and the use of secondary sources to support the process." Fieldwork practitioner survey F27

2.3.5 Three-step fieldwork planning tool for progressive fieldwork experiences

The taxonomy of fieldwork post-Covid-19 (Figure 2.7) that can be used to describe fieldwork can also be used to form the basis of tool to plan fieldwork. The addition of a rationale (based on the author's own reflections and experiences on planning fieldwork) and the numbering provides facilitators with the opportunity to plan fieldwork experiences using a three-step process (Figure 2.15).

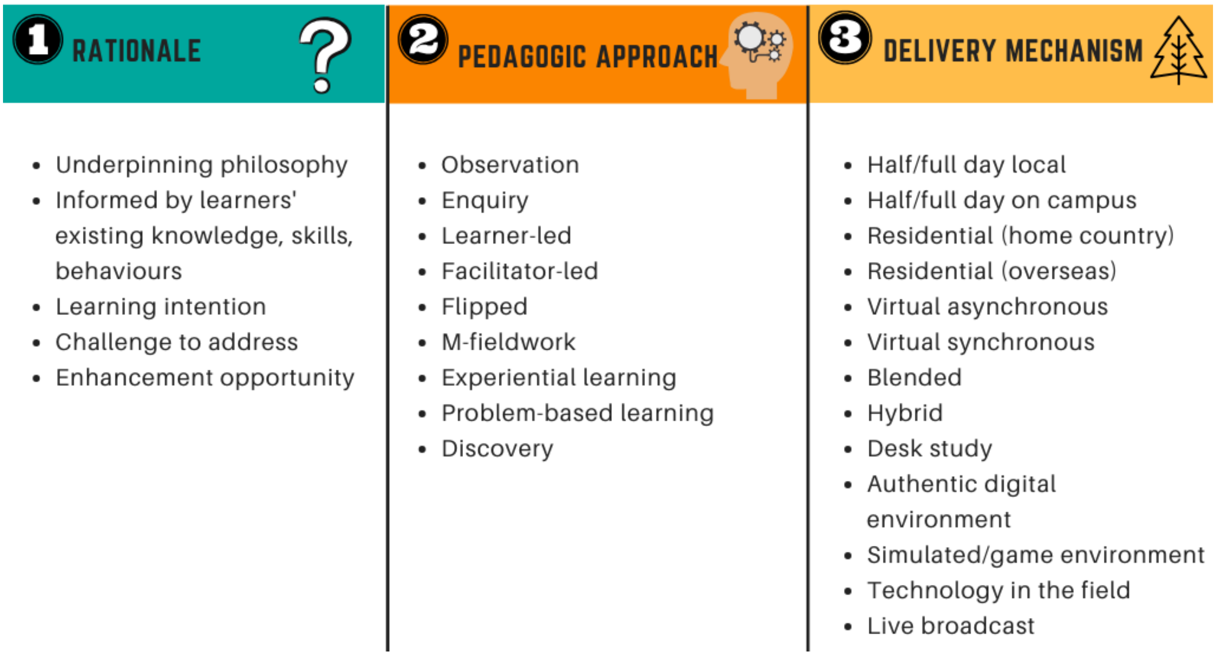

Figure 2.15 Three-step fieldwork planning tool constructed from the analysis of data from the review of the literature, expert panel interviews and fieldwork practitioner survey and the author's own reflections and experiences on planning fieldwork. Step 1. Rationale: Purpose for the fieldwork. What learning is the fieldwork intending to address? Step 2 Pedagogic approach: What is the underlying pedagogy which will be used during this fieldwork? Step 3 Delivery mechanism: How will the fieldwork be delivered to its intended audience?

Step 1 supports facilitators to develop a rationale for a fieldwork experience and consider what learning is the fieldwork intended to address. As in this research, a review of user need informed by identifying the existing challenges of fieldwork from both a learner and facilitators perspective is a useful starting point to inform the development of the rationale. The completion of the rationale can be informed by a combination of the following: department philosophy, learners' current knowledge, skills and behaviours, a specific challenge that the fieldwork is aiming to address, enhancement opportunity that the fieldwork can provide and an overall learning intention.

This planning tool (Figure 2.15) enables individual fieldwork occasions to be defined in terms of rationale, pedagogic approach, and delivery mechanism. Facilitators may then use this tool to plan and justify fieldwork occasions considering both individual learner needs and equality and inclusion principles. Additionally, the common approach and language of the tool means that individual fieldwork occasions do not need to be developed in isolation, with the tool offering the affordance to plan progressive fieldwork experiences across a particular module, year of study or even degree programme, with learners having multiple opportunities for fieldwork informed by various pedagogic approaches and delivered using different delivery mechanisms.

Table 2.16 illustrates how the planning tool (Figure 2.15) was used to define a second-year, 20 credit fieldwork module within the biosciences. Each individual learning activity had a distinct rationale and was described in terms of pedagogic approach and delivery mechanism.

Table 2.16 Applying the three-step fieldwork planning tool to a second-year undergraduate fieldwork module.

Code	**Activity/Session**	**Rationale**	**Pedagogic Approach**	**Delivery Mechanism**
1.	Overview of module.	Learners understand the purpose, logistics and assessment of the module.	Facilitator-led.	In-person lecture and discussion.
2.	Fieldwork planning, preparation teamwork and inclusivity.	Build fieldwork knowledge.	Facilitator-led.	In-person lecture and discussion.
3.	First aid, health, and safety. Mental health, wellbeing and belonging.	Build knowledge and skills relevant for successful fieldwork.	Facilitator-led.	In-person lecture and discussion.
4.	Virtual habitat-marine.	Preparation resources to build learner confidence, of the fieldwork environment.	Learner-led enquiry.	Synchronous virtual fieldwork in an authentic environment.
5.	Digital Field Notebook and recording data in the field.	Build fieldwork knowledge.	Facilitator-led observation, m-fieldwork.	Technology in field.
6.	Information on individual projects.	Information of topics available for small group projects.	Facilitator-led.	Lecture.
7.	Virtual habitat-woodland and freshwater.	Preparation resources to build learner confidence, and address novelty of	Learner led enquiry.	Synchronous virtual fieldwork

		the fieldwork environment.		in an authentic environment.
8.	Mapping and app recording.	Build fieldwork knowledge.	Facilitator-led.	In-person lecture and discussion.
9.	Gosforth Nature Reserve field visit.	Apply fieldwork skills learned from virtual environments.	Facilitator-led enquiry.	Half day local fieldwork.
10.	Intro to R- reading in data.	Build knowledge and skills related to analysis of fieldwork data.	Facilitator-led.	In-person Workshop.
11.	Meet your project groups.	Students work in groups to design a fieldwork enquiry.	Learner-led flipped learning.	Desk study.
12.	Group planning.	Students work in groups to design a fieldwork enquiry.	Learner-led flipped learning.	Desk study.
13.	Millport residential fieldwork.	Students work in groups to collect fieldwork data to support the fieldwork enquiry.	Learner-led enquiry.	Residential (home nation).
*****	Digital preparation resources (optional).	Prepare students for fieldwork covering basics to address potential knowledge and skills gaps.	Blended.	Virtual asynchronous fieldwork.

In evaluating the role of both learners and facilitators during each of these individual fieldwork learning activities, a progressive fieldwork pathway can be identified within this fieldwork module (Figure 2.16). Students were provided with multiple opportunities to build fieldwork knowledge through in-person lectures and seminars, apply that knowledge during practical workshop activities, half-day field trips and engagement with authentic virtual environments, before embarking on an extended learner-led fieldwork enquiry during a residential fieldwork component. Optional digital preparation resources were available for learners to use at any point during the module to address any self-identified gaps in fieldwork knowledge and skills. The purpose of this module was for learners to become more independent and play a more active learning role, as facilitators transition in their role from teacher to mentor (Figure 2.16). Due to the progressive nature, with learner and facilitator reflection, each learning activity can be adapted according to learner need based on individuals' development throughout a progressive fieldwork experience, promoting a fieldwork learning environment that is inclusive and responsive to need.

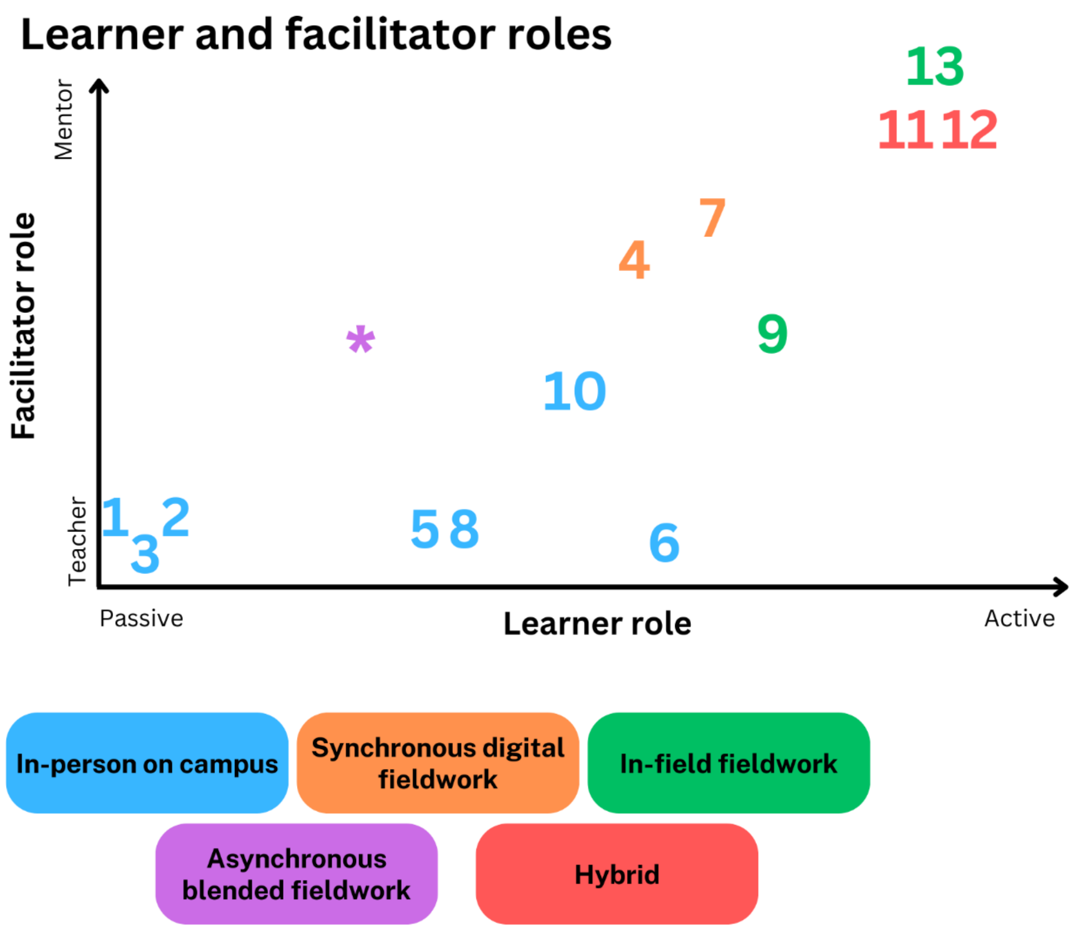

Figure 2.16 Reflecting on intended learner and facilitator roles during a second-year undergraduate fieldwork module. Numbers refer to the individual fieldwork activity/session as described in Table 2.16. Colours summarise how each individual fieldwork activity/session could be described.

Table 2.16 and Figure 2.16 represent how the three-step fieldwork planning tool can be used by facilitators to plan progressive fieldwork experiences. The participatory workshops within this research involved working with students who had participated in this fieldwork module and asking them to define the fieldwork activities and plot these individual learning sessions on the same axes. Figure 2.17 is a collated summary of the three participatory workshops and illustrates participants' reflections of the facilitator and learner roles during the module. Key similarities are coded in yellow, and key differences are coded in red.

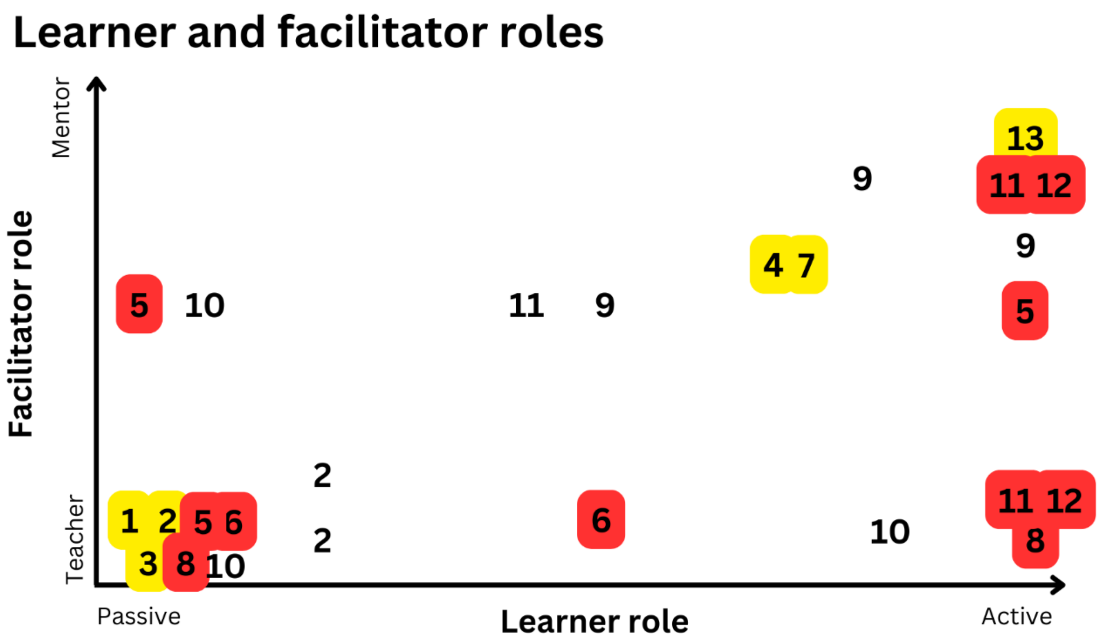

Figure 2.17 Collated outputs from the participatory workshops illustrating participants views on learner and facilitator roles during a second-year undergraduate fieldwork module. Numbers refer to the individual fieldwork activity/session as described in Table 2.16. Key similarities between participatory workshops are coded in yellow and key differences are coded in red when compared to Figure 2.16 (the intended learner and facilitator roles).

There was a strong agreement on the placement of both synchronous digital fieldwork sessions (4 and 7), as well as those initial sessions intended to build fieldwork knowledge (1, 2 and 3) with a student commenting on how the virtual environments offered opportunity for them to think practically about sampling during the fieldwork (Table 2.17). The in-field residential fieldwork (13) had strong agreement in its placement across the participatory workshops with students defining their role as active, and the facilitator role as mentor. Students identified that the previous fieldwork activities supported them in their active role during the residential fieldwork component (Table 2.17). Key differences between the different participatory workshops (Figure 2.17) and the expected roles (Figure 2.16) centred around the role of the facilitator during the group planning sessions (11 and 12), where students identified the facilitator role are both extremes, teacher, and mentor. One student commented on how the facilitator acted as a mentor to guide their discussion during the group planning (Table 2.17) while another student shared that information was given to them (Table 2.17). Some lessons (5, 6 and 8) were intended for learners to play a more active role such as being engaged with decision making and in trialling some of the digital tools (e.g., apps on personal mobile device). However, some students identified their role in these sessions are predominantly passive (Table 2.17).

Table 2.17 Student quotes from the participatory workshops explaining some of the key similarities and differences between participants' views on learner and facilitator roles during a second-year undergraduate fieldwork module.

	Quote from participatory workshop
Think practically.	*"…being able to look around and sort of see that environment as if you're in it. I think it gets you thinking a lot more on the practicality side of things. Whereas it's very easy just to understand theory on sampling techniques and stuff like that. But you have to start thinking about, how am I going to fit the transect in this section of woodland and stuff like that." Participatory workshop S172*
Supported active role.	*"So we had already like built up the skills on how we plan by doing the other one (Gosforth). So it's kind of easy for us all to come to the same conclusion when we were out there, I think… Because we'd already built up the skills by planning the project (in the group planning sessions)…Because we could see it like in the flesh (virtual resources). I think it'd be hard to do it if we were just came here." Participatory workshop S164*
Facilitator as mentor.	*"I reckon the group planning was us being really active and the mentor coaching us, as it was a discussion rather than actual like you are doing that." Participatory workshop S166*
Facilitator as teacher.	*"Yeah, because at the beginning, it was him telling us information about eider ducks, that we didn't know." Participatory workshop S157*
Uncertainty on learner role.	*"They sounded like really good apps and stuff to use, but I didn't kind of know does this apply to us? Should I figure out how and when to use the app right away or not?" Participatory workshop S170*

2.4 Discussion

This research combined a review of the literature with expert panel interviews, a fieldwork practitioner survey, and student focus groups to examine the practice of fieldwork post-Covid-19 and perspectives on digital fieldwork. It sought students' perspectives on the defining characteristics of digital fieldwork before examining the challenges and opportunities of in-field and digital fieldwork as identified by practitioners.

2.4.1 An emerging model to define a broadened field of practice

This research presents a taxonomy of fieldwork based on practitioner experience and perspectives, with an emerging model identified to describe the broadened field of practice within fieldwork. This extends the work of other research where a timeline of change can be constructed up until 2020 (Kent *et al*., 1997; Fisher 2001; Peasland *et al*., 2019; Bacon and Peacock, 2021). The taxonomy of fieldwork that is constructed from this research can be used to define recent developments in fieldwork post-Covid-19 (Creech and Shriner, 2020; McKinnon, 2020; Cowles and Onthank, 2021; Verdes *et al*., 2021; Novo *et al*., 2021; Middlebrooks and Salewski, 2021; Stagg *et al*., 2022).

Existing definitions of fieldwork (Butler, 2008; Krakowka, 2012) do not account for the expanded digital delivery modes that emerged after Covid-19 (Bacon and Peacock, 2021; Middlebrooks and Salewski, 2021; Novo *et al.*, 2021). Unlike Butler (2008) and Krakowka (2012), who base their definitions on the type of fieldwork activity, the approach presented in Figure 2.6 distinguishes between pedagogy and the delivery mechanism, allowing for a more precise definition. This distinction is crucial for digital fieldwork, where numerous combinations of delivery mechanisms and pedagogic strategies exist. This model is a step towards consistent and accepted terminology both within geosciences (Foley *et al*., 2024) and in the biosciences.

While existing descriptions of virtual fieldwork environments (Klemm and Tuthill, 2003; Duncan *et al*., 2012) do give detailed information on both the content of the approaches and the digital tools used in each approach, no information is shared on the underlying pedagogy nor the justification of the approach. In including a rationale within the three-step planning tool (Figure 2.14) it can be used to define the fieldwork but also support the communication of the purpose and value of the approach, which we have identified within this research as important for both practitioners and students alike.

The three-step fieldwork planning tool provides an opportunity for pedagogic led fieldwork developments. Its use alongside some axes depicting student and facilitator roles support its use as a relational fieldwork planning tool, whereby future fieldwork or a review of existing fieldwork using the tool provides opportunities for progression within fieldwork to be mapped. It provides a method to embed fieldwork within programmes of study, potentially minimising the risk of fieldwork being seen as a separate peripheral subject (Cook *et al.*, 2006) tackling the issues of integrating fieldwork (Wilson *et al.*, 2017) and providing opportunities to view fieldwork as more than single field trip (Burke Da Silva, 2014). There is potential for facilitators to use this tool to provide learners with multiple opportunities to develop different fieldwork skills across a variety of different delivery mechanisms. This would build repeated fieldwork exposure which can improve confidence and skills (Peacock *et al.*, 2018) and supports the view that virtual fieldwork is a more forgiving learning environment (Puhek *et al.* 2013).

While the fieldwork taxonomy model does not explicitly reference specific digital tools, it is based on a comprehensive literature review and insights from practitioners through expert panel interviews and a fieldwork practitioner survey. Given the rapid pace of digital innovation, the model should be considered *'live'* to remain adaptable to future technological advancements in fieldwork.

2.4.2 Move to viewing collaboration in delivery mode of fieldwork as a new normal

Within this research, fieldwork practitioners have identified that digital fieldwork offers both opportunities and presents challenges. The data suggests that these are, on the whole, unique to the digital fieldwork delivery mode; and are not the same challenges and opportunities shared within in-field fieldwork. This offers evidence to challenge the notion that in-field fieldwork is at risk from digital fieldwork approaches (Boyle *et al*., 2007), as the fieldwork practitioners within this study (expert panel interview n = 10 and fieldwork practitioner survey n = 57) identified distinct challenges and opportunities in both fieldwork delivery modes. This supports Barton’s (2020) findings that the outcomes of field-based teaching were difficult to replicate using remote digital delivery modes, suggesting that the purpose and outcomes of digital fieldwork are different to those in-field. In providing only in-field or digital fieldwork to learners, facilitators run the risk of inhibiting learners to acquire certain skills and limiting opportunities of the broader benefits of fieldwork which both students and facilitators of fieldwork have identified as unique to each approach. This research supports the view that a planned fieldwork program that encompasses a range of fieldwork delivery mechanisms and pedagogic approaches could present a new normal in fieldwork practice, where both digital and in-field modes have relevance and their use depends on individual contexts (Leininger-Frézal and Sprenger, 2022). The different delivery mechanisms and pedagogic approaches are used in combination to plan progressive fieldwork learning through field trips which incorporate a digital component, provide opportunities for collaboration and open science (Geange *et al*., 2021), integrative learning (Durrant and Hartman, 2015) and build scientific, professional, and digital skills (Nicotra *et al*., 2022; Maddison *et al*., 2023a), presenting a blended approach to fieldwork learning.

This current research supplies some detail on the student experience of a progressive fieldwork experience within the biosciences, which incorporates both in-field and digital fieldwork components and their views on both student and facilitator roles. Yet more needs to be done to communicate these roles during the different delivery modes as evidenced by a lack of consensus between students and facilitators on these roles within this research. Additionally further examples of using the three-step fieldwork tool to plan progressive fieldwork experiences should be sought from a broader range of fieldwork contexts including GEES disciplines within HE and from pre-HE fieldwork such as International Baccalaureate and A Level geography and biology fieldwork.

2.4.3 Identified barriers to adoption of digital fieldwork

Access to technology was the highest frequency challenge of digital fieldwork identified by practitioners within this research. Pre-pandemic, access to technology was the highest remote learning barrier in field-based education (Barton, 2020). Despite this current research occurring post-pandemic, access to appropriate technology remains a challenging factor in the successful adoption of digital fieldwork. The useability of the digital tools and the intuitive user-experience identified as characteristics of digital fieldwork from the review of the literature and shared by students as a technology consideration within the defining characteristics of digital fieldwork offers support to the ‘Bring Your Own Device’ (BYOD) approach (Welsh *et al*., 2018), with students accessing the digital fieldwork approach via their own familiar mobile device.

A pre-pandemic view of the challenges for introducing technology in fieldwork (Welsh *et al*., 2013) shows similarities to the findings from this research post-Covid-19. The pre-pandemic study found that staff and learner competency and willingness was a challenge to technology introduction (Welsh *et al*., 2013); this study found that the need to prepare learners to use digital resources was the second highest frequency challenge of digital fieldwork identified from the fieldwork practitioner survey and expert panel interviews. Learners require time to become proficient in using digital technologies (Medzini *et al*., 2015) and require opportunities to develop their knowledge and skills needed to access these learning opportunities (Dolphin *et al*., 2019). Even though facilitators and learners alike have had prolonged experiences of digital fieldwork during the pandemic, these challenges of access to technology, willingness and competency with digital fieldwork remain an issue.

Additional challenges were identified in this current research that did not emerge within a pre-pandemic study of challenges to technology introduction in fieldwork (Welsh *et al*., 2013). These included challenges in the delivery of digital fieldwork, with practitioners identifying that differentiation, personalisation and offering interaction was difficult to achieve using digital approaches. Although remote teaching has been identified as a less engaging mode of learning for learners (Barton, 2020), the role of learners as active participants, who are immersed in the digital fieldwork and provided with interactive opportunities, has been identified as vital characteristics from the review of the literature and from students and practitioners participating in this current research. This active learner role is something which should be a key consideration in the design of digital fieldwork approaches.

2.4.4 Identified opportunities to adoption of digital fieldwork

This research identified the potential for digital fieldwork to provide opportunities for engagement with data and the development of digital skills such as data processing and spatial-temporal modelling; with practitioners sharing specific examples. This supports an earlier view of virtual fieldwork environments whereby they offer opportunities for learners to interact with time and space (Stainfield *et al*., 2000), something which is difficult to replicate during in-field fieldwork.

Students within the focus groups in this research identified the benefits of a blended approach, acknowledging that digital fieldwork should be used to build knowledge and skills prior to in-field fieldwork, with the preparatory materials used to inform their fieldwork plans and decision-making. Preparing learners with logistics has been strongly related to positive learning outcomes (Lee *et al.*, 2020), and also was identified as a characteristic in the review of the literature within this research. Additionally using technology in the field presents an opportunity for engagement with data and digital resources post-fieldwork (Welsh *et al*., 2013), and students within this current research were also able to identify the benefits of digital fieldwork resources post-fieldwork, with learners sharing that their understanding of virtual fieldwork material is better if it was accessed after an in-field field visit.

Data from this research provides a view of blended fieldwork, suggesting that fieldwork practitioners and students alike see opportunities for fieldwork to become a fully integrated blended approach with digital resources being used before, during and after in-field fieldwork experiences. This supports a view that digital fieldwork is supplementary (Rogers, 2020), provides a vital link between classroom and field (France *et al.*, 2020) with learners having access to digital resources and activities prior to in-field fieldwork whilst still retaining access post-fieldwork for review, reflection and revisiting of content. This integration of face to face and online has been identified by students as key to sustain a sense of a student centred community (West *et al*., 2023).

Access and equity were identified characteristics of digital fieldwork from the review of literature, with the digital delivery mechanisms supporting access to fieldwork environments for a broader range of learners. It is positive to note that students also identified access and equity as defining characteristics of digital fieldwork, with digital fieldwork playing a role in increasing access to locations, removing cost barriers and providing equivalent digital fieldwork experiences to those who are unable to access an in-field fieldwork occasion. Equality and diversity was identified as a challenge within a recent horizon scan of ecology teaching (Cooke *et al.*, 2020), with diversity gaps identified in field courses (Beltran *et al.*, 2020). Digital fieldwork is recognised by students and fieldwork practitioners within this current research as a tool to support equality, diversity, and inclusion (EDI) within fieldwork. However these digital fieldwork tools do little to address the systemtic structural barriers to EDI (Zavaleta *et al*., 2020) present within fieldwork education.

2.5 Limitations

Limitations were identified with the methods associated with this chapter (and in subsequent chapters 3, 4 and 5. The review of the literature used only a single database (SCOPUS) and did not take into account grey literature within this field. This could mean that there are fieldwork practices that organisations or individuals (who were also not captured within the expert panel interviews or practitioner surveys) have shared via reports or resources that are not peer-reviewed and therefore do not form part of the Fieldwork Taxonomy model constructed within this research. Therefore, we must not view the pedagogic approaches and delivery mechanisms as exhaustive, instead viewing it as a live model.

In conducting content analysis, both inductively and deductively, the process of distilling rich qualitative data into themes and codes can diminish the integrity and completeness of the data, potentially failing to capture the full depth of meaning within the frequency data. To minimise this throughout this thesis, example quotes from the raw data are used to illustrate the themes and ensure that both student and practitioner voice is a strong aspect within this research. Although themes from inductive content analysis were discussed with the supervisory team, second coders were not used and therefore no measure of inter-coder reliability have been reported. Therefore, the content analysis data analysis performed on both the expert panel interviews and practitioner surveys and the subsequent findings presented within the challenges and opportunities section of the findings (section 2.3.4) remain a subjective interpretation of the findings from this chapter.

Reflexive thematic analysis is prone to interpretative bias; in ensuring transparency the foreword of this thesis includes information on the author's motivations for this research as well as detail on the positionality of this research and the researcher.

PCA assumes linear relationships among variables, which may not hold true for this dataset, or for any ecological data set, including those on humans. As a result, the analysis may not accurately capture the underlying structure of the data. Additionally, the PCA was conducted on a limited dataset, making it more susceptible to the influence of outliers. In small samples like this, the impact of outliers can be amplified, potentially skewing results, meaning small datasets like this may yield PCA findings that are not generalisable.

2.6 Summary

Both the potential opportunities of digital fieldwork identified by practitioners and the defining characteristics of digital fieldwork identified by students show no overlap with the opportunities of in-field fieldwork. This supports a view that digital fieldwork is not a direct replacement for in-field fieldwork experiences, but rather offers alternative opportunities for learners, which are not easily achieved during in-field fieldwork, and that practitioners and students alike are able to identify these characteristics and opportunities of a digital fieldwork delivery mode.

The broadened range of practice present within fieldwork across disciplines can now be defined. This taxonomy presents a potentially valuable tool for facilitators and learners alike to define, plan and communicate their broadened fieldwork practice.

Chapter 3. Designing digital tools to enhance fieldwork

Abstract

Although there are numerous studies on the use of digital tools in fieldwork education, often they are case studies of an approach or share facilitators and/or learner perspectives on the tools but give little information on how these perspectives then inform future development.

In this research three digital tools were presented as a minimum viable product to a student trial group. Each of the three tools; Digital Field Notebook (DFN) (n = 7), Digital preparation resources (n = 6) and Virtual Field Trips (VFTs) (n = 6) underwent a process evaluation using student surveys and student focus groups to determine the student experience of using the digital tools and their underlying understanding of the purpose of the digital tool. Using a 'Student as partners' (SaP) approach, feedback on the digital tool was sought with areas for development identified and implemented.

When trialling the resources, students identified that each of the digital tools supported the development of knowledge-based, transferable, and personal attributes skills with students identifying the VFTs offering the most skill development opportunity. Feedback from the user-testing group identified technology, content, and pedagogy feedback themes. Based on this feedback, 27 developments across 11 feedback themes were made to the digital tools. Informed by student voice the TPACK framework can be applied to all three digital tools. A model of a blended fieldwork environment is constructed from this research which offers further detail on how digital preparation tools can be embedded within fieldwork and facilitate communication between students and facilitations. Despite these developments some challenges remain for these digital tools. Students found it challenging to determine the purpose of the VFT and despite finding the DFN easy to use, barriers to the use of mobile devices in the field were shared.

This research showcases the value of working with students during the development of digital tools for use in fieldwork with student voice captured and refining a DFN, digital preparation resources and VFTs.

3.1 Introduction

3.1.1 Existing digital tools in fieldwork

Digital tools in fieldwork perform a variety of different functions, which are summarised below:

- Mobile data collection- use of mobile devices to collect, collate and geo-locate fieldwork data (Welsh *et al*., 2012; Bettinson and Bird, 2021; Park, 2021; Maddison *et al*., 2023a).
- Virtual field trips- virtual representation of a fieldwork location (Klemm and Tuthill, 2003; Lee, 2009; Friess *et al*., 2016; Šašinka, *et al*., 2019; Mead *et al*., 2019; Cowles and Onthank, 2021; Jeffery *et al*., 2021; Peace *et al*., 2021; Ruan *et al*., 2021; Rodríguez *et al*., 2022; Horota *et al*., 2023; Hutchinson *et al*., 2024; Juergensmeier *et al*., 2024).
- Augmented Reality (AR)- offering an interactive experience which enhances the real-world (Oleksy and Wnuk, 2017; Gazcón *et al*., 2018; Verdes *et al*., 2021; Rodríguez *et al*., 2022; Majewska and Vereen, 2023; Arrasyid *et al*., 2024; Hagge 2024).
- Gamification of fieldwork environments- developing a game-like approach, which encourages engagement and supports motivation (Rader *et al*., 2021).
- Live broadcast- real-time transmission of fieldwork teaching over the internet (Stagg *et al*., 2022).
- Blended approach to fieldwork- digital and in-field are combined pre- and post-fieldwork (Moore and Gilmartin, 2010; Durrant and Hartman, 2015; Geange *et al*., 2021; Nicotra *et al*., 2022; Wallgrün *et al*., 2022; Oktavianto *et al*., 2023; Husby *et al*., 2024).

3.1.2 Understanding the fieldwork context

The nature of fieldwork requires learners to navigate real and complex environments (Lonergan and Anderson, 1988). To support this, experienced researchers spend time observing the fieldwork environment before considering their research design and methodology (Bowen and Roth, 2007). Observation has been identified as one of the top five important fieldwork skills that learners acquire during fieldwork (Maw *et al.*, 2011). Despite the importance of progressive fieldwork experiences which increase learners' autonomy throughout both an individual field trip and the fieldwork program of an entire degree (Kent *et al*., 1997; Peasland *et al*., 2019), many learners are generally given little time to develop observation skills before collecting fieldwork data for staff-derived fieldwork enquiries (Bowen and Roth, 2007). One way to support the fieldwork learning environment is to connect the local fieldwork location to a larger scale issue or concept (O'Connell *et al*., 2020), yet little is known about how learners can be supported through this process in making their own observations, connecting these observations to real-world issues at a variety of scales, and how this informs the acquisition and cementing of ecological knowledge. Another way is to consider how the experiential learning cycle (Kolb, 2015), where knowledge is created through experience can be applied within a fieldwork context (Healey and Jenkins, 2000; Krakowka, 2021; Burden, 2017, McPhee, 2021), although this is under-explored within the literature when considering the role of digital tools to support this.

When conducting fieldwork, learners' experience cognitive, geographical, social, and psychological novelty (Cotton and Cotton, 2009). Although some learners find novel aspects of the fieldwork environment transformative, for others they present barriers to the fieldwork itself (Morales *et al*., 2020). Removing these barriers is not always possible, but building comfort, connection, confidence, and capabilities with the fieldwork experience can support learners to overcome these barriers (Bowser and Cid, 2021).

This skill building and fostering a sense of belonging in the field can be achieved by formative, online pre-fieldwork resources that introduce learners to the field (Geange *et al*., 2021; Greene *et al*., 2021) and improve learners' self-efficacy in fieldwork (Race *et al*., 2021). Preparation work such as schedules and logistics can also be important to support neuro-divergent learners in the field (Lang and Persico 2019; Kingsbury *et al*., 2020; Taylor and Johnson, 2020) with facilitators recommended to take these steps to make fieldwork more accessible and inclusive for all learners (Yorke *et al*., nd).

In both the biosciences (Cowles and Onthank, 2021) and geography (Šašinka, *et al*., 2019; Mead *et al*., 2019, Horota *et al*., 2023; McDougall, 2024), the fieldwork environment has been digitised producing a variety of virtual fieldwork experiences that offer open exploration of fieldwork environments (McDougall, 2024) and replication of fieldwork tasks via guided instruction (Friess *et al*., 2016; Rodríguez *et al*., 2022). During the Covid-19 pandemic many facilitators adopted virtual fieldwork alternatives when in-person access to fieldwork environments was limited (Bryson and Andres, 2020) but fieldwork outcomes were difficult to replicate with technology barriers and lower engagement levels from learners (Barton *et al*. 2020). Yet many of these virtual fieldwork environments represented a rapid pivot to a digital alternative in unprecedented times. This research, which will incorporate students in the development of digital fieldwork tools, aims to address some of the issues that have been identified in other studies.

3.1.3 Role of learners in designing digital tools for fieldwork

The creation of some digital fieldwork tools such as Virtual Field Trips (VFTs) is a time consuming and technical process (Stott *et al*., 2009). Learners are often removed from this process, playing a passive role in the majority of studies into digital fieldwork (Tang, 2013; Medzini *et al*., 2015; Welsh *et al*., 2015; Adekola *et al*., 2017; Dolphin *et al*., 2019; Adams *et al*., 2020; Lee *et al*., 2020; Bos *et al*., 2021; Senger and Nordmo, 2021; Xie *et al*., 2021; Rodríguez *et al*., 2022; Wallgrün *et al*., 2022; Wright *et al*., 2023; Arrasyid *et al*., 2024); often providing feedback on a tool without it being clear if or how this feedback is incorporated into re-development of the approaches. This presents an opportunity to work with these students to design and integrate digital tools within fieldwork in the biosciences. While some suggest that students raised alongside technology can be considered 'digital natives' (Prensky, 2001), it is crucial to recognise that their digital skills are not uniform. Therefore, involving students in the design of digital tools for fieldwork and considering their experiences and feedback is vital to ensure that the tools meet their digital capabilities.

Incorporating student voice can be considered via student representation or student participation (McCulloch, 2009). Working in partnership via co-design processes has broad benefits for students including increased awareness of teacher and student roles (Garcia *et al*., 2018), understanding of collaboration (Prescott *et al*., 2020; Woods and Homer, 2021) and development of graduate skills (Pauli-Hones *et al*., 2016).

Working with 'Students as Partners' (SaP) would aim to address the need for a more thorough reflection on the learning process of using some digital tools (Senger and Nordmo, 2021). Additionally, empowering student voice in co-design is one way to promote inclusive practice within fieldwork (Lawrence and Dowey, 2022). Promoting equality, diversity, and inclusion (EDI) through working with students remains an underlying principle of this research and seeks to add to the growing literature on developing inclusive practice within fieldwork education (Chiarella and Vurro, 2020; Kingsbury *et al.*, 2020; Lawrence and Dowey, 2022; Yorke *et al*., nd).

This research will present three developed digital tools at a minimum viable product (MVP) stage. A MVP is defined as *"an early, basic version of a product (typically a computer program or piece of technology) that meets the minimum necessary requirements for use but can be adapted and improved in the future, especially after customer feedback"* (Oxford Languages, 2024).

These three digital tools underwent a process evaluation, which aimed to uncover the student experience of using the digital tool and the underlying understanding of the purpose of the digital tool. Feedback on the digital tool was sought, with areas for development identified and incorporated into the redevelopment of the three tools.

3.1.4 Research aim and objectives

The overarching research aim (RA) of this chapter is to consider to what extent students can be involved in the designing digital tools to address pedagogic challenges and enhance fieldwork (RA2). To address this aim, this chapter will focus on three research objectives (RO). First, it will identify the student experience of pedagogic challenges associated with fieldwork (RO2.1). Second, it will identify the student experience of using each of the three developed digital tools (RO2.2). Third, it will use student voice to develop these three digital tools (RO2.3).

3.2 Proposed digital tools- Minimum Viable Product (MVP)

This educational research can be defined as Action Research (AR), whereby digital tools have been developed by this researcher in response to both practitioner perspectives and student voice outputs of an exploration phase (see Chapter 2) and to address a specific challenge in fieldwork within the fieldwork context. A MVP version of three digital tools was developed for testing with small groups of students in the trial phase.

3.2.1 Digital Field Notebook (DFNs)

A Digital Field Notebook (DFN) is a catch all-term used to describe the use of a mobile device to collect both quantitative and qualitative data using in-build functions of the device and additional applications (apps) (Maddison *et al*., 2023a). DFNs are useful and bring together the functionality of both fieldwork apps and geo-location capabilities while offering presentation and analysis of data in the field (France *et al*., 2015; Senger and Nordmo, 2021).

Using ArcGIS Survey 123 app, a custom DFN survey was created. Each individual student could download their own version of the DFN onto their personal mobile or tablet device and add their own DFN entries during their fieldwork. The DFN would aim to replace the paper-based notetaking that students might complete during fieldwork. The DFN enabled data collection on the following aspects:

- Reflection: Impact of the fieldwork on cognitive, psychomotor, affective, and conative outcomes.
- Field notes: Sketches, photos, mind maps and qualitative notes.
- Nature Connection: Uses the pathways to nature to foster students' connection to nature (Lumber *et al*., 2017).
- Interpreting the environment: Interrogate the fieldwork location, consider socio-political implication and real-world application of the fieldwork.

3.2.2 Digital preparation resources

In-field data collection is not the only fieldwork task of importance with preparation, de-briefing and feedback sitting alongside the fieldwork practical tasks (Kent *et al*., 1997). Although not all learners recognise the value of effective classroom preparation in contributing to their learning (Lavie Alon and Tal, 2015), prior exposure has been identified as a factor to address learners' lack of interest in fieldwork (Fleischener *et al*., 2017).

Using ArcGIS StoryMaps, eight individual preparation resources were created that covered some of the knowledge, skills, and confidence gaps that learners face before fieldwork (Chapter 2). These included: Health and Safety, Ethics, Fieldwork Outcomes, Residential Fieldwork Experience, Kit and Equipment, Desk Study, Why Fieldwork and Nature Connections. Embedded tasks guided students to engage with each of the preparation resources.

3.2.3 Virtual Field Trips (VFTs)

A VFT provides learners with opportunities for exploration, discovery, and analysis within a digital representation of a fieldwork environment (Mead *et al*., 2019). In-field tasks can be replicated digitally including species identification and the use of photo-quadrats for sampling (Cowles and Onthank, 2021). The VFT can use video (Friess *et al*., 2016), adopt tools to support collaboration between users (Lee, 2009; Wang *et al*., 2021a), and can draw upon gamification principles including avatars, multiple views, and 3D-VR visualisations (Šašinka, *et al*., 2019).

Using ArcGIS StoryMaps, a series of linked VFTs were created that enabled exploration of sand dune and salt marsh ecosystems in the UK. The VFTs incorporated videos, GIS maps, photos, and fieldwork data, with guided tasks to support students to carry out fieldwork in the VFTs.

3.3 Context underpinning the research

Inspired by the arguments for AR by Papadopoulou (2020), this research focused on actionable knowledge. Students are active participants with their ideas contributing to change. By working in partnership with students (Healey *et al*., 2014), students are empowered and engaged in supporting an iterative design process of each of the digital tools. Responsive feedback mechanisms (Viswanath *et al*., 2019) and a co-creation process (Gros and Lopez, 2016) were in place to identify feedback themes and construct developments to each of the digital tools. This research is underpinned by a pragmatic epistemological basis, in particular it is informed by a Deweyan pragmatism as shared in Hammond (2013) where individual experiences help to form an individuals' sense of reality, but it also acknowledges the role that a researcher plays in forming that understanding. This collaboration between myself as both a researcher and fieldwork practitioner, and valuing student voice strives to ensure that outputs from this research are grounded in the experience.

3.4 Methods

3.4.1 Trial phase

The three proposed tools (section 3.2.1, 3.2.2, 3.2.3) underwent a process or 'trial' evaluation to determine whether the DFN, digital preparation resources and VFTs had been received by the users as intended. It considered the process behind the adoption and use of each of the digital approaches. This trial of the three digital tools valued student voice in the testing phase. It uncovered views and experiences of using the digital approaches, considered the barriers and enablers to using the tools, and used this student feedback to develop each of the tools. In response to some of the issues with low-response rate and over-testing associated with student evaluations in Higher Education (HE) (Porter *et al*., 2004; Adams *et al*., 2012), this trial of the three digital tools was conducted by three separate small groups of students who were each given access to one of the digital fieldwork tools. This enabled the focus to be on developing a partnership approach that honoured student voice to gather quality feedback on the digital tools. Screenshots of the three digital tools post-trial phase are included later in this chapter (Figures 3.11; 3.13; 3.15).

Table 3.1 summarises this trial phase for each of the proposed digital tools. The length of the testing phase was determined by a combination of factors including extent of the digital tools, length of field trip and participants availability.

Participation within the trial phase was voluntary, and all participants provided consent in line with the ethical approval granted by the School of Natural and Environmental Sciences at Newcastle University (Ref: DFN- Ref: 18717/2022; digital preparation resources- Ref: 21545/2022; VFTs- Ref: 26230/2022).

Table 3.1 Information on trial phase participants for the three proposed digital tools.

Digital tool	**Digital Field Notebook (DFN)**	**Digital Preparation Resources**	**Virtual Field Trips (VFTs)**
Number of students.	Seven.	Six.	Six.
Student codes.	S23-S29.	S30-S35.	S36-S41.
Context.	Level 5 marine undergraduates. Resources used during UK-based winter residential field trip.	Level 5 biosciences undergraduates. Resources used during UK-based spring residential field trip.	Level 5 biosciences undergraduates and Level 5 biosciences undergraduates undertaking a year-long fieldwork placement.
Length of testing phase.	Seven days.	Six days.	Three weeks.
Process evaluation method.	Two in-person focus groups. Student surveys.	One in-person focus group. Student surveys.	Four online interviews (Based on request of participants, two interviews each had two participants). Student survey.

3.4.2 Student focus groups

Semi-structured in-person focus groups were conducted on the last day of the testing phase (DFN and digital preparation resources). The focus group questions were designed using a 'funneling approach' (Breen, 2006). Firstly, starting with general introductory questions, on students' experiences of the field trip. Then the questions asked the trial group about awareness, attitudes, and behaviours of using the digital tool. Finally, users' ideas for improvements and developments to the digital tool were discussed. Focus groups lasted approximately 60 minutes and were recorded and transcribed. A copy of the focus group schedule is included within Appendix 3.1.

3.4.3 Student interviews

At the end of the three week testing phase for the VFTs semi-structured online interviews were conducted. As the participants of this trial phase were remotely located, and undertaking a fieldwork placement, an online interview was appropriate to suit participants availability. Some students requested a joint interview with the researcher, and this was accommodated. The semi-structured interviews followed the same structure as the student focus groups (See 3.4.2 and Appendix 3.1). Each interview lasted approximately 60 minutes. Interviews were conducted via Zoom, recorded, and transcribed.

3.4.4 Student survey

After each testing phase participants completed a survey. Using a mix of open and closed questions, it aimed to capture the student experience of using each of the digital tools and gather feedback on the challenges experiences, what they liked, a reflection on the skills developed and suggestions for improvement. A copy of each of these surveys is included within Appendix 3.2.

3.4.5 Data analysis

Data from the focus groups, interviews and the open questions from the survey were analysed using qualitative data analysis. The students' experiences of each of the underlying pedagogic challenges was analysed using deductive content analysis to identify positive and negative facilitating factors related to each of the challenges (RO2.1). Inductive content analysis was used to list student identified purpose of each of the digital tools which provides information on the experience of using the tools (RO2.2). Two frameworks were applied to the data to support deductive analysis related to specific research objectives. Firstly, a skills framework informed by Peasland *et al*., (2019) was used to categorise student self-reported skill development into knowledge-based skills, transferable skills and those skills which are personal attributes. This informed the research objective related to student experience of using the digital tools (RO2.2). Secondly, as in other digital fieldwork research where it was used as a theoretical lens (Foley *et al*., 2024) the Technology Pedagogy and Content Knowledge (TPACK) framework (Koehler and Mishra, 2005; Voogt *et al*., 2013) was applied to the data to identify the intersecting knowledge required to support the integration of the tools which provides vital information on the student experience of using the tools (RO2.2). Additionally, these same categories from the framework (technology, pedagogy and content) are used to summarise the feedback suggested by students to inform the development of the digital tools (RO2.3).

Quantitative data from the survey was analysed using descriptive statistics where percentages were used to summarise data related to student response of the ease of use of each of the digital tools and the likelihood of using each again. This informed the research objective related to student experience of using the digital tools (RO2.2).

Student quotes are used throughout the analysis to illustrate the themes and outcomes shared within the findings.

3.5 Findings

3.5.1 Student experience of the pedagogic challenge

Student users shared their lived experience of each of the challenges that the digital tools were designed to address. Student reflections were summarised into themes and coded as to whether they were positive or negative facilitating factors related to the challenge (Figure 3.1), selected quotes are used to illustrate these themes (Table 3.2).

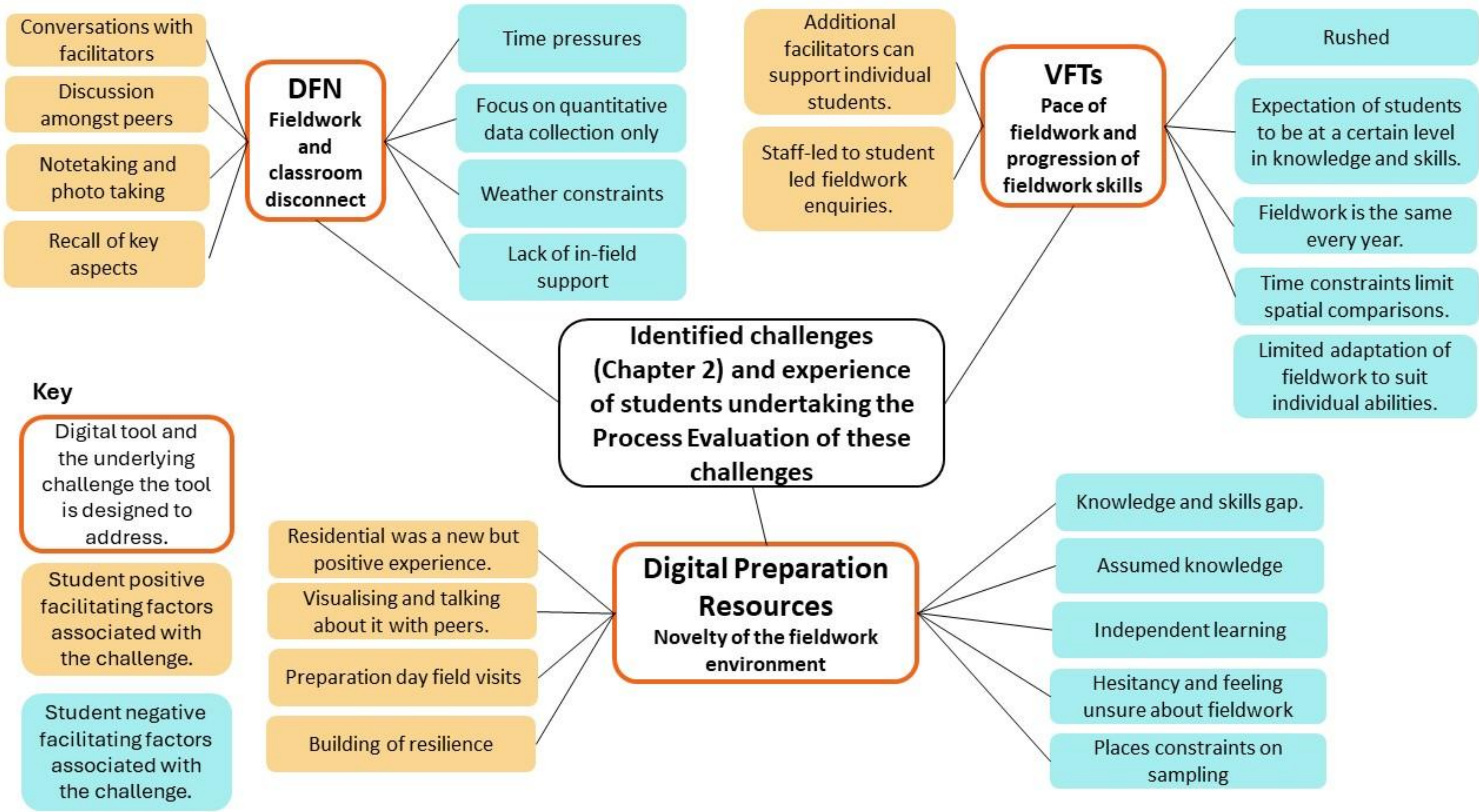

Figure 3.1 Student users' experience of the three challenges that the three digital tools are designed to address. Experiences are coded into themes categorised into whether the experiences were a positive influencing factor (yellow) or a negative influencing factor (blue).

The DFN testing group reflected upon four positive influencing factors and four negative influencing factors associated with the challenge of the disconnect between the classroom and the field. The negative factors associated with this challenge included the time pressures of fieldwork, where the fieldwork is focussed solely on quantitative data collection (Table 3.2). Weather conditions during fieldwork were also highlighted as a negative influencing factor on the opportunity to spend time connecting their learning with classroom content (Table 3.2). Students identified that support from facilitators in-field was a positive influencing factor that helped to connect the fieldwork to classroom, but a lack of this support negatively affects that connection (Table 3.2).

The VFT testing group reflected upon two positive influencing factors and five negative influencing factors associated with the challenge of the pace and progression of fieldwork. One of the positive influencing factors related to pace and progress during fieldwork was access to additional facilitators who could support students in field (Table 3.2). Additionally, a transition during field courses from staff led to student led was also a positive influencing factor related to pace and progression (Table 3.2). Students identified that one of the negative influencing factors related to the pace and progression of fieldwork was an expectation of students to be at a certain level in their fieldwork knowledge and skills, with facilitators of fieldwork offering only limited adaptations to suit individual needs of students (Table 3.2). Students identified that rigid and tight timings during fieldwork negatively affected their pace and progression. Time in the field often felt rushed, with limited time for spatial considerations in different locations and/or environments (Table 3.2). The student testing group of the digital preparation resources also identified that assumed knowledge was a negative influencing factor on the novelty of the fieldwork environment (Table 3.2). Students identified that there was a knowledge and a skills gap between what they knew already and what they needed to know to complete the fieldwork (Table 3.2). This resulted in students feeling unsure and being hesitant about the fieldwork environment (Table 3.2).

There were several positive influencing factors related to the novelty of the fieldwork environment. Students identified that visualising and talking about fieldwork with their peers was helpful (Table 3.2) as well as the opportunities to undertake day field trips prior to embarking on residential fieldwork (Table 3.2).

Table 3.2 Student quotes to illustrate some of the themes in Figure 3.1 and whether these themes were categorised as a positive or negative influencing factor.

	+/-	Theme	Student quote to illustrate influencing factor theme
Digital Field Notebook (DFN).	-	Time pressures.	*"Like quite often we literally have just enough time. But barely enough time to collect the bare…minimum to get the data that they want us to get…it just means that…you don't think of anything else…How many are there? 123456. Write that down, move onto the next one." S24*
	+	Conversations with facilitators.	*"…sometimes the lecturers that are out there, like will ask you more like prompting questions and kind of help you." S29*
	-	Lack of in-field support.	*"…depends on if we get that interaction with the lecturer while you're out. Sometimes you can just be left to your own devices…"S23*
Virtual Field Trip (VFT).	+	Additional facilitators.	*"What's really nice with the labs at my Uni is that we have PhD students and Master's students actually come and assist. So, you'll have your key lecturer, who is in charge of the module. But then you will have their assistants…Who will go bench to bench like, Are you okay? Are you struggling with anything? Have you read through it? Do you understand what's going on?...Yeah, that really makes a difference." S36*
	+	Staff led to student led fieldwork enquiries.	*"So my fieldwork last year the first two days we all went together and did certain fieldwork, and were taught how to do it. And the final three days in groups, we could create our own project and do what we wanted. So, I thought, (that) kind of progressed us, doing what we want and like coming up with our own methods...." S37*
	-	Expectation of students to be at a certain level	*"So I came in, and I found some of the stuff quite sort of you know. I've done this. I know what I'm doing. I'm quite confident here. But I saw other people who came in with no*

		in knowledge and skills.	*experience going. Oh, this is new, and I'm expected to already be familiar with it." S39*
	-	Rushed.	*"And it always, well, it's quite often, it feels quite rushed as well… So the timings very much dictate the pace." S40*
	-	Limited time for spatial comparisons.	*"…with the time constraints difficult to get those locational comparisons in." S38*
Digital preparation resources.	-	Assumed knowledge.	*"I think like the main problem is that it was assumed that we knew more about what fieldwork was... Yeah you will construct a question when you get here. But yeah I don't know how to think of an idea from…Like I don't have a clue." S33*
			"…this is the first field trip I have done, like ever. I didn't really even know what was happening at all." S34
	-	Knowledge and skills gap.	*"Practically we have never ever done anything like this before, not on this scale. I've not touched a transect since like four years…I've never done a project like that even in the lab…it's the first time we've had to curate our own idea.." S32*
	-	Hesitancy and feeling unsure about fieldwork.	*"I felt kind of unsure about doing fieldwork because I didn't really know what I was supposed to be doing. Because like actually being out in the field is so different to anything we got told last year." S32*
	+	Visualising and talking about fieldwork with peers.	*"Me and XX talked about it before the trip. Thinking about like what to bring, what are we going to be doing, that sort of thing." S30*
	+	Preparation day field visits.	*"…having the opportunity to go on local half day or day field trips is useful to prepare you for what a more intense field trip might be like." S35*

3.5.2 Student experience of using the digital tool

The students were asked to reflect upon the ease of use each of the digital resources (Figure 3.2). Seventeen out of 19 students reported that the digital tool they tested was either easy or very easy to use. However, despite the DFN app being easy to use, when asked about the ease of using a mobile device during fieldwork, five out of the seven students identified that using a mobile device in the field was more difficult or very difficult.

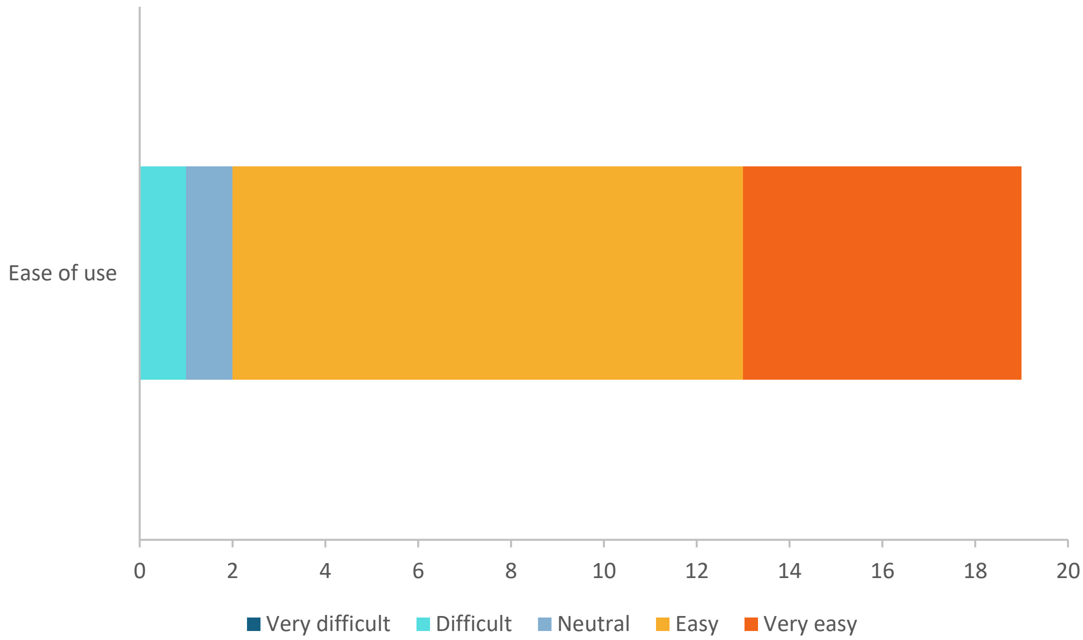

Figure 3.2 Student user feedback on the ease of use of all digital tools combined (n = 19).

The students were asked to reflect upon the likelihood of using the digital resources again (Figure 3.3). Overall, the digital tools were viewed positively with 63% (12 out of 19) saying that they would be likely or extremely likely to use the digital tool that they had tested again, Table 3.3 uses student quotes to illustrate the positive and negative learner experience of using the digital tools.

Students shared specific content features of the VFTs and design features of the digital preparation resources that they liked (Table 3.3.) Although there were aspects of the DFN that students liked, five students identified that they would be unlikely to use the digital tool again; all of these were students who had tested the DFN. Some students shared their thoughts of using their mobile device during fieldwork (Table 3.3). Although the DFN was part of their fieldwork students were still hesitant to use the DFN in the field. Students shared that they were not sure whether they had permission to do so, with the use of the mobile device seen as a distractor in the field (Table 3.3).

Table 3.3 Student quotes to illustrate the positive and negative learning experience of using digital tools.

	Student quote
Positive learning experience of using the digital tools.	*"I like them a lot, very informative using iNaturalist (data) and 3D models gave an overall perspective of the sites that would allow me to better understand the fieldwork and engage with it." S39*
	"I really liked the step by step for a field sketch, the dune plant identification was well explained, and the images were very helpful for the plant ID." S36
	"Interactive resources i.e. videos, links and maps. Kept learning engaging. Also there were very clear aims and objectives for each section." S34
	"Easy to navigate, clear set up of info, interactive." S30
	"It helps me to take in my surrounding and reflect on the fieldwork a bit more." S23
	"Can attach pictures so I remember which site was which." S24
	"Chance to note other things other than data." S28
Negative learning experience of using the digital tools.	*"Hard to use in certain weather conditions." S27*
	"Cannot type when fingers are cold and wet." S23
	"And if your phone gets wet it's not very useful" S25
	"I need to get in the mindset of you actually can use your phone." S29
	"I don't think I have ever been told that technology and learning go hand in hand. One is recreational. One is educational." S26

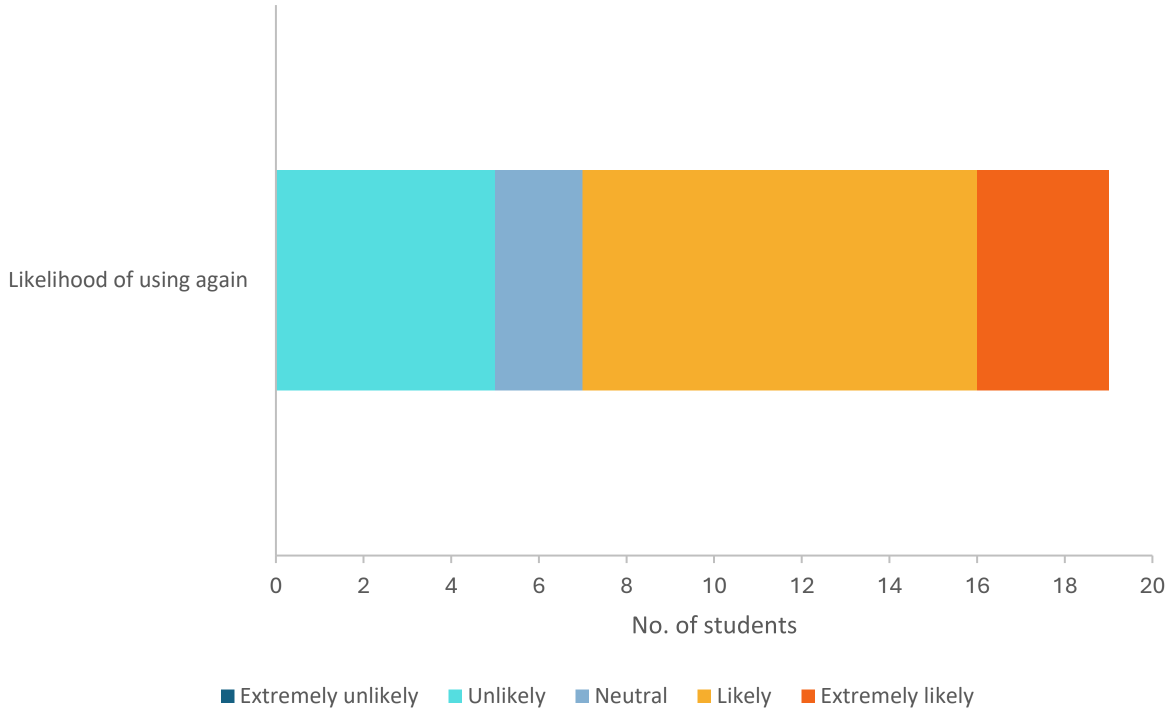

Figure 3.3 Student user feedback on the combined likelihood of using the digital tools again (n = 19).

Although each digital tool was designed to address a specific identified challenge, students within the trial phase were asked to define the purpose of the digital tools. The identified purpose are summarised in Table 3.4 with student quotes shared in Table 3.5.

Table 3.4 Purpose of each of the digital tools as identified by student users in the process evaluation trial phase.

Digital tool	Purpose of tool as identified by students
Digital Field Notebook (DFN).	Digital notepad. Collect and collate data from multiple users. Engage with and better understand the fieldwork environment. Revision tool post-fieldwork.
Digital preparation resources.	Prepare for and become familiar with fieldwork. Develop knowledge and skills about fieldwork.
Virtual Field Trips (VFTs).	Background information to sites and further reading. Improve access of opportunity and accessibility of the fieldwork environment. Revision tool post-fieldwork. Prepare for/assist delivery of in-field fieldwork. Better understanding of the importance of fieldwork.

The students identified that the purpose of the digital preparation resources matched the intended area of challenge that the resources were designed to address (Table 3.5).

For the DFN, the students identified that the purpose matched the intended role of the tool, and some of the defining characteristics of the DFN (Table 3.5). The purpose of the VFTs as defined by the student user group was quite broad, with five purposes identified including preparation, improving the inclusivity of fieldwork, and using the VFTs alongside existing fieldwork as a revision tool (Table 3.5). The broad purpose identified led to some confusion about the VFTs (Table 3.5).

Table 3.5 Student quotes to illustrate the purpose of the digital preparation resources, digital field notebook (DFN) and the virtual field trips (VFTs).

	Student quote defining purpose of each of the digital tools
Digital preparation resources.	*"To give background info about the basics of fieldwork including equipment, environment and what to expect." S33*
	"To prepare students for all aspects of fieldwork in advance." S35
Digital Field Notebook (DFN).	*"It allows us to record the atmosphere of fieldwork and act as a digital notepad with photos to refer to as revision." S24*
	"To gain a better understanding and recollection of the environment to look back (on) and maybe evaluate why the data gotten was how it was." S26
Virtual Field Trips (VFTs).	*"To give a wide and in-depth insight into the field and prepare me for onsite fieldwork so I know what I need to do from the start." S39*
	"To enable those without the opportunity or access to the real-world environments to experience the habitats and understand the importance of fieldwork." S36
	"It improves fieldwork accessibility as it means that students who may struggle more out in the field, or is unable to attend, can still participate in a form of fieldwork." S37
	"To be used to assist the delivery of fieldwork, such as a follow up of fieldwork a student has carried out or revision purposes." S38
	"I'm struggling to understand the purpose of the resource, is it supposed to replace physical fieldwork, or be used as an extra resource?...I do think the resource is generally very well developed, but the main question I have is what is the purpose of the resource? This would help to understand the reasoning for including or excluding certain elements. I currently see it as a good revision tool, because I think it misses some important skills gained from conducting physical fieldwork." S38

After trialing the resources, students in the three individual trial groups were asked to reflect upon whether the resources had enabled them to develop any skills. In the DFN trial group, two out of the seven students identified that they had developed skills, two were unsure and two students said they did not develop any skills. One student did not complete this question. In the digital preparation resources, five of the six students said they had developed skills, with one student who was unsure if they had developed skills when using the digital preparation resources. In the VFT trial group, all six students identified that they had developed skills.

Table 3.6 categorises the skills identified for each of the three digital tools with Table 3.7 providing some student quotes on the skills developed. Students identified the most skills when trialing the VFTs, which offered opportunities for them to develop specific knowledge-based skills such as numeracy and GIS, as well as personal attributes such as confidence and self-management.

Table 3.6 Student self-reported skill development when using each of the digital tools. Informed by Peasland et al., (2019) skills are categorised into knowledge-based skills, transferable skills and those skills which are personal attributes.

	Knowledge	**Transferable**	**Attributes**
Digital Field Notebook (DFN).	Observation.		Self-reflection. Critical thinking.
Digital Preparation.	Map.	Risk assessment.	
Virtual Field Trips (VFTs).	Map. Data/numeracy. IT/digital GIS.		Confidence. Resilience. Self-management. Personal interest.

Table 3.7 Student quotes reflecting on any skills that were developed when using the digital field notebook (DFN), digital preparation resources and the virtual field trip (VFT).

Digital tool	**Student quote reflecting on any skills developed when using the digital tool**
Digital Field Notebook (DFN).	*"Maybe skills of reflection." S24*
	"I've been more critical of my decisions in the field." S25
	"Self-reflection and looking at logging locations." S27
Digital preparation resources.	*"Deepened my knowledge and appreciation for risk assessment as well as surveying a site prior to the actual data collection." S31*
	"We were already doing the skills that the StoryMaps were introducing us to so not many skills were newly developed." S35
Virtual Field Trip (VFT).	*"It allows the development of IT, data analysis and numeracy skills when you are completing the tasks, as well as the development of fieldwork drawing. Also, working through it on your own allows you to develop resilience and self-management skills needed to get it done." S37*
	"Looking at maps and interrogating the data." S39

The TPACK framework can be applied to each of the three digital approaches, with student comments from the survey and focus groups used to illustrate the intersecting knowledge required to support the integration and use of each of the digital tools. This is summarised for the DFN (Figure 3.4), the digital preparation resources (Figure 3.5), and the VFTs (Figure 3.6)

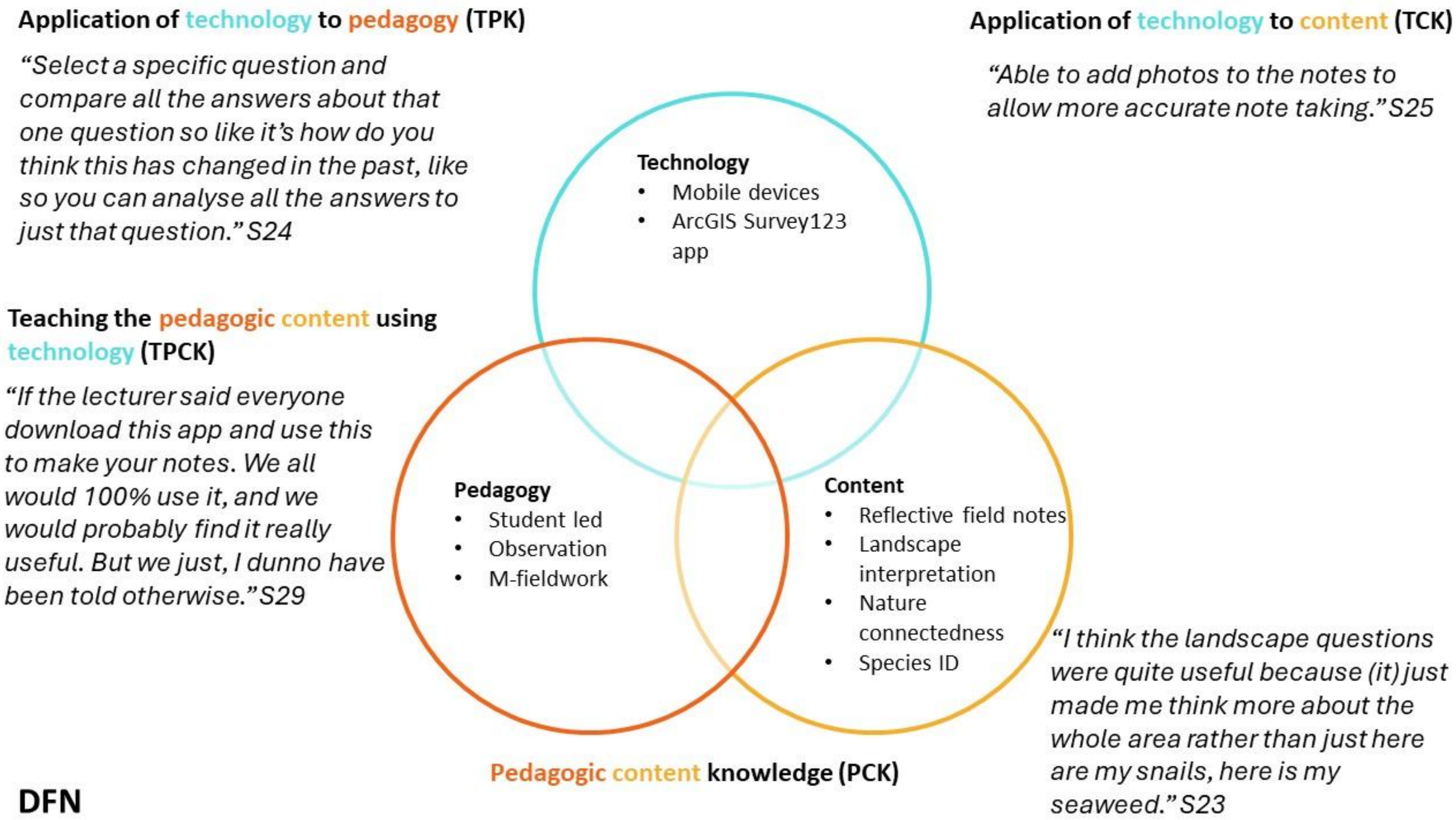

Figure 3.4 Applying the TPACK framework to the digital field notebook (DFN) with student quotes illustrating the identified knowledge required to support integration.

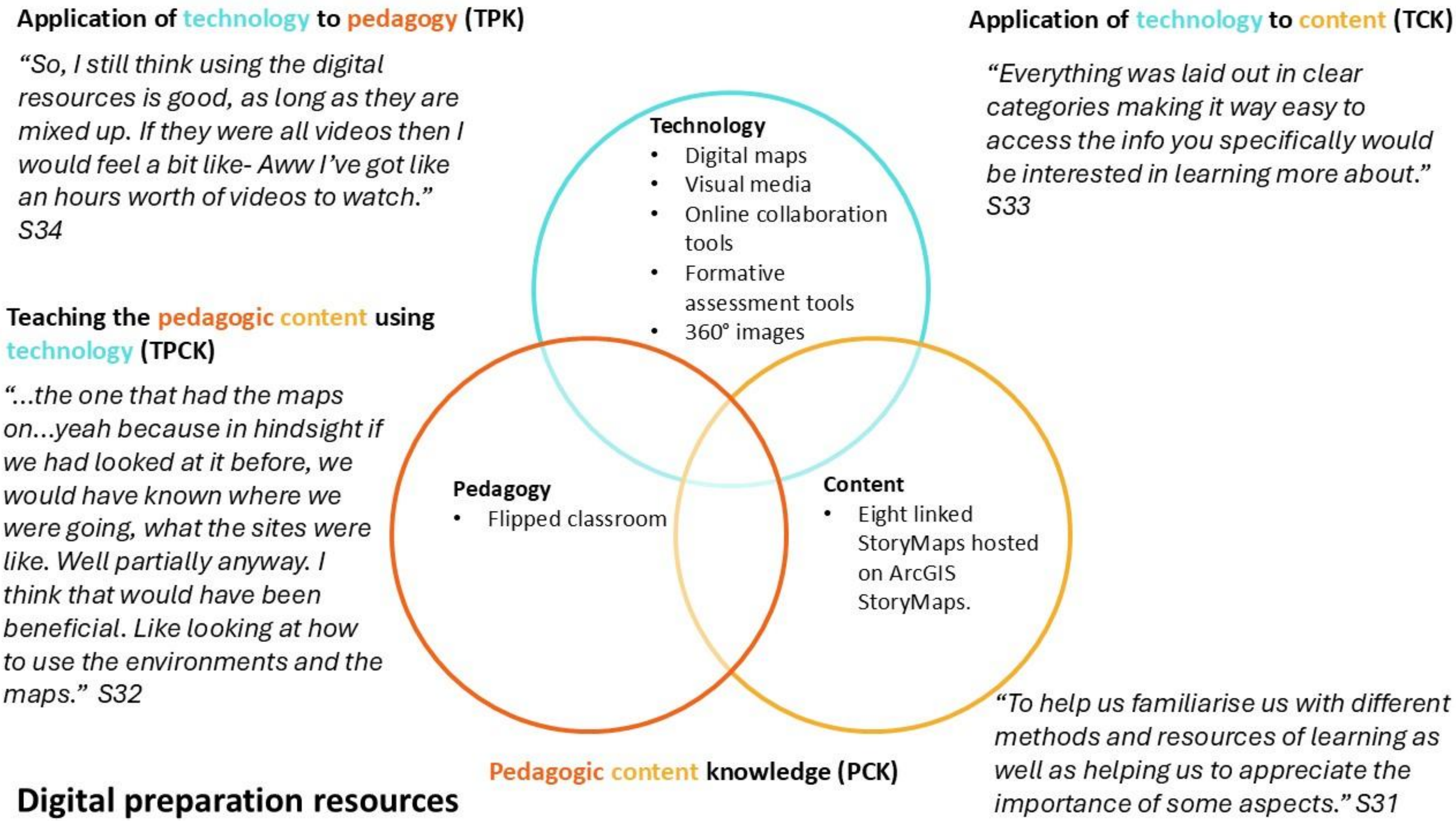

Figure 3.5 Applying the TPACK framework to the digital preparation resources with student quotes illustrating the identified knowledge required to support integration.

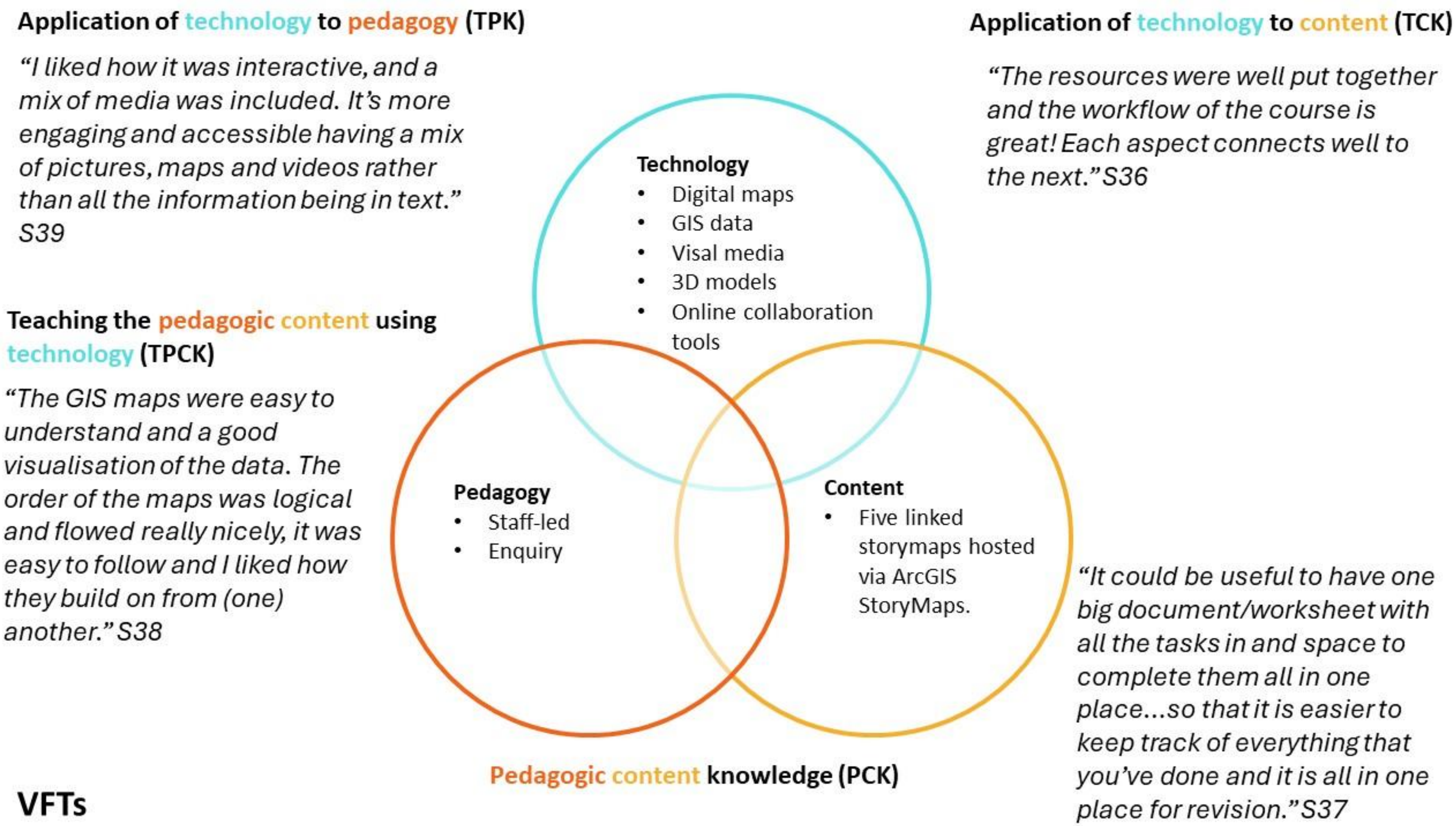

Figure 3.6 Applying the TPACK framework to the virtual field trip (VFT) resources with student quotes illustrating the identified knowledge required to support integration.

3.5.3 Using student voice to develop digital tools

Based on student feedback gathered from the focus groups, interviews and survey, feedback themes were identified for each of the three digital approaches (Table 3.8) with student quotes used to illustrate these feedback themes (Table 3.9).

Table 3.8 Student feedback themes summarised under pedagogy, content and technology feedback of the three digital tools.

	Feedback themes to develop the digital tools		
	Pedagogy	**Content**	**Technology**
Digital Field Notebook (DFN).	Time to reflect. Permission to use. Seeing value in the DFN.	Applicability to fieldwork. Streamline questions. Emotional literacy.	Single map. Removal of barriers to using technology in the outdoors.
Digital preparation resource.	When to use and access. Formative assessment. Assumed knowledge. Emotional literacy. Facilitate communication pre-fieldwork.	Specific content. Real-life experts and examples.	Variety of mixed-media and tasks.
Virtual Field Trips (VFTs).	Formative assessment. More engagement and interactivity needed. Complimentary to the outdoors. Clarify purpose of VFT.	More GIS. Extra links and reading to stretch and challenge. Question prompts next to videos. Focus on follow-up.	Suggest use of VR. Consideration of access to resources. Need to bookmark progress.

There were several feedback themes that occurred across more than one of the digital approaches. For example, formative assessment was a feedback theme for both the digital preparation resources and the VFTs (Table 3.8). Students require more embedded opportunities to assess their understanding at various stages when using the digital resources, so that they can then act upon that themselves to guide their future learning or have their facilitators of fieldwork act upon that information (Table 3.9). All three of the digital tools had feedback themes related to 'seeing value', 'when to use' or to 'clarify purpose'. This highlights that all the students who trialed the digital tools struggled to understand how the tools could be used and embedded within their existing fieldwork studies (Table 3.9). One student suggested alternatives to when the resources might be useful (Table 3.9). Students also identified technology barriers to using two of the digital tools, with using the DFN outdoors problematic for students in some fieldwork situations (Table 3.9). They also identified technology access issues to using the VFTs (Table 3.9).

Table 3.9 Student quotes to illustrate a selection of the feedback themes for the development of the digital tools.

Theme	Student quote illustrating feedback theme
Formative assessment.	*"And I know it sounds really silly and childish but it's like testing you, and it's easy and takes five, ten minutes." S32*
	"More interactive things to test knowledge." S26
	"You did this bit. You watched the video. Test, what you learned…Here's a couple of questions, or make some notes in this box." S36
Seeing value; When to use; Clarify purpose.	*"I think this is something that I really struggled to see with the resource… because I couldn't tell whether it was trying to replicate like field, actual fieldwork or just kind be a revision tool." S37*
	"In the field, rarely able to find time and remember to use the app." S24
	"…it felt a bit rigid, getting our phones out and doing it…Like if I'm being honest out in the field, I wouldn't want to do that… I don't mind writing stuff down if it I know it's going to be relevant later on. But maybe it's drilled into use that you shouldn't take them out in this kind of environment, weather and all this kind of stuff." S25
	"This would have been a really helpful thing to give everyone a better idea of what they could do if they picked this module this year." S25
Technology barriers.	*"Actually using the app in the field, like getting your phone out when it's cold and wet." S25*
	"Again, in the field it's sometimes like pissing it down with rain, it's windy and it's cold and your hands are getting freezing, and it's hard to type. It sounds pathetic but it's like what being in the field is like." S24
	"…if you didn't have good wi-fi access to the resources to be able to get on with the digital resources it would limit you quite a lot especially with like loading the videos, and the stuff that takes more wi-fi… I think if you had like a smaller laptop, it could get a bit like fiddly and difficult." S37

	"I know a lot of people now are moving to having the subtitles on. It gives you more of that if you are experiencing it in two ways, being able to read and hear, at the same time it cements in the memory. So, I think, yeah, it would definitely be beneficial. Perhaps I wouldn't have needed to rewatch the video if I had subtitles." S36

Based on the feedback themes identified during user testing, developments were made to the DFN (Figure 3.7), digital preparation resources (Figure 3.8), and the VFTs (Figure 3.9). In total 27 developments were made with 11 overall development areas.

Two of the DFN development themes adjusted the DFN to be more user-friendly through the streamlining of the questions, reducing the total number of questions and making questions optional for the user, as well as enabling students to edit their own DFN entries.

The developments made to the digital preparation resources help to situate these resources within the real-world via connecting the value of fieldwork through GIS and fieldwork careers, and within facilitators of fieldwork own practice, by providing formative assessment opportunities which offer a chance for facilitators to review learners' assessment and adjust future teaching accordingly.

Developments that fostered peer collaboration were added to the digital preparation resources and the VFTs, meaning students could use embedded digital collaboration tools such as surveys and discussion boards within the digital fieldwork resources. This means that although students may be accessing the resources remotely, there is an opportunity for asynchronous peer communication. The majority of the VFT development themes (Improved clarity, Accessibility, Support and Challenge) enabled the VFT digital fieldwork resources to be useful to the widest range of learners.

Section 3.6 summarises the final co-designed digital tools (See 3.6.1 DFN; See 3.6.2 Digital preparation resources; See 3.6.3 VFTs).

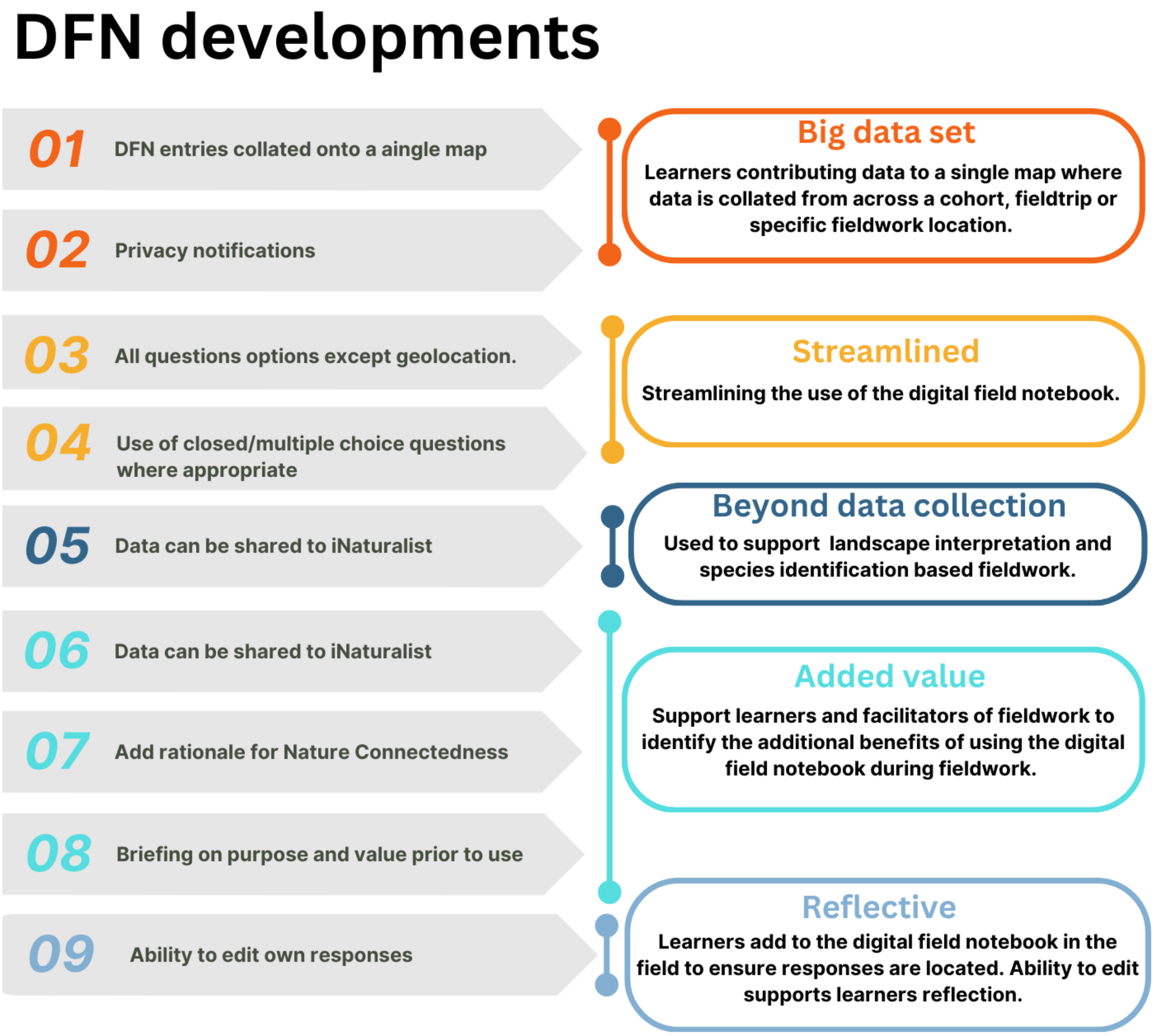

Figure 3.7 Nine developments made to the Digital Field Notebook (DFN) informed by student feedback. These nine developments were grouped into five development areas (big data set, streamlined, beyond data collection, added value, reflective).

Digital preparation resources developments

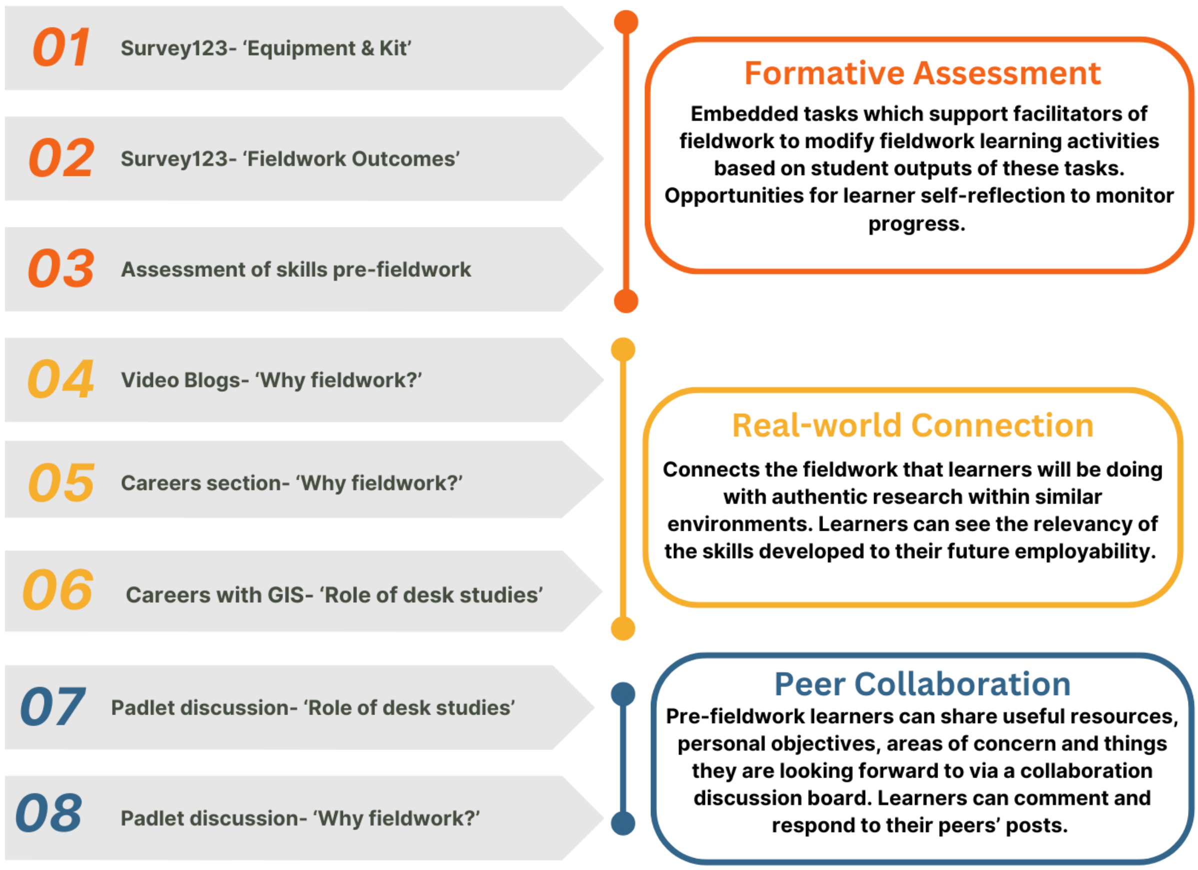

Figure 3.8 Eight developments made to the digital preparation resources informed by student feedback. These eight developments were grouped into three development areas (formative assessment, real-world connection, peer collaboration).

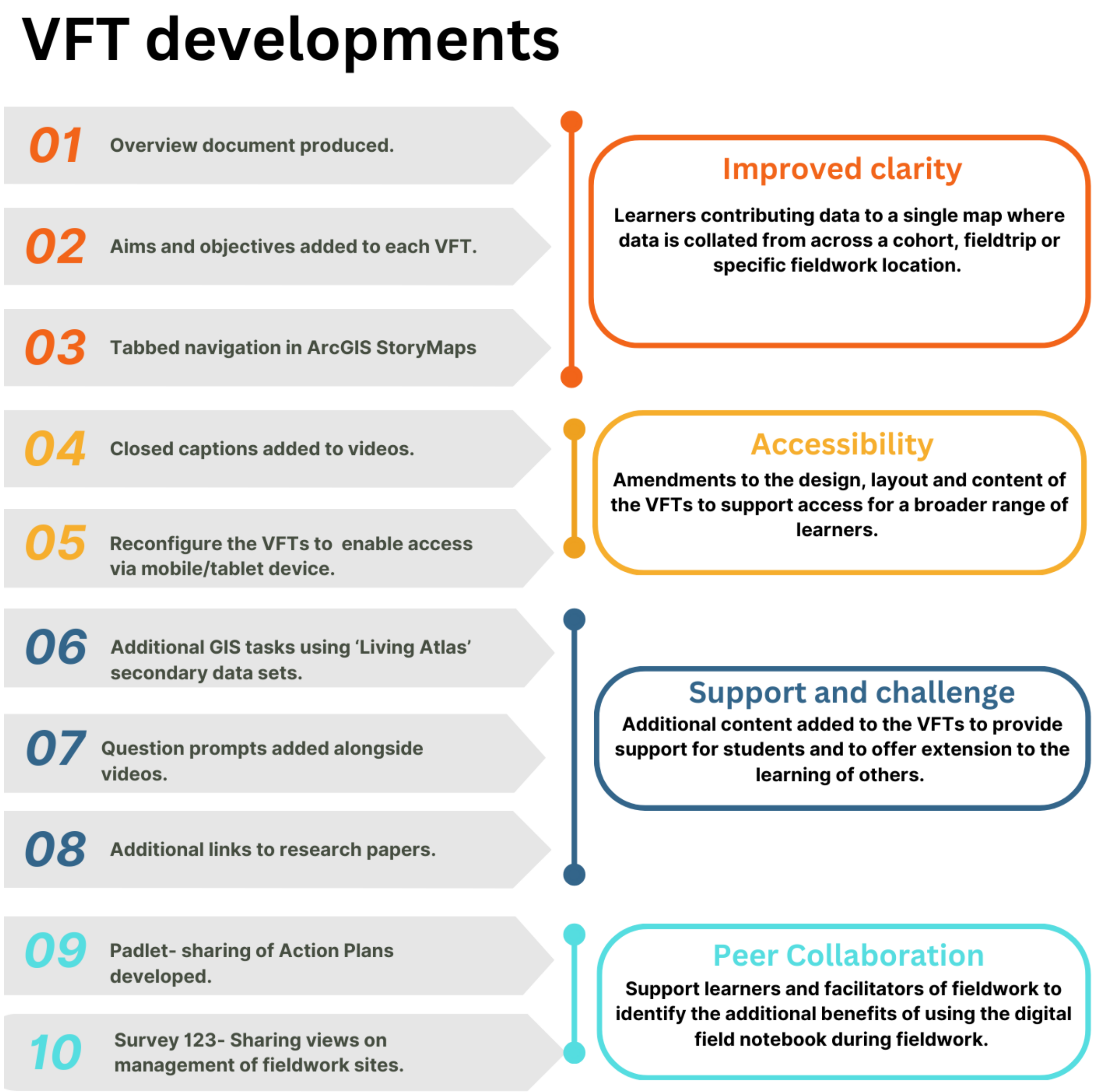

Figure 3.9 Ten developments made to the Virtual Field Trip (VFT) informed by student feedback. These ten developments were grouped into four development areas (improved clarity, accessibility, support and challenge, peer collaboration).

Beyond the developments to the digital preparation resources, student feedback was used to construct a model to support how and when the digital preparation resources could be used by students and facilitators of fieldwork (Figure 3.10). This presented a way of integrating the digital preparation resources through the construction of a model of a blended learning environment, which was constructed from this research. It highlights value in a reflective process where learners using the preparation resources develop fieldwork skills prior to embarking on in-field fieldwork. There are multiple facilitator and learner touch points within this model. Formative assessment opportunities within the digital fieldwork resources enabled the in-field fieldwork to be adapted based on these outcomes. Accompanied by the students accessing tailored skill development within the digital preparation resources, having conducted a pre-skill assessment, the hope being that this approach to fieldwork builds the fieldwork knowledge, skills, and confidence of learners.

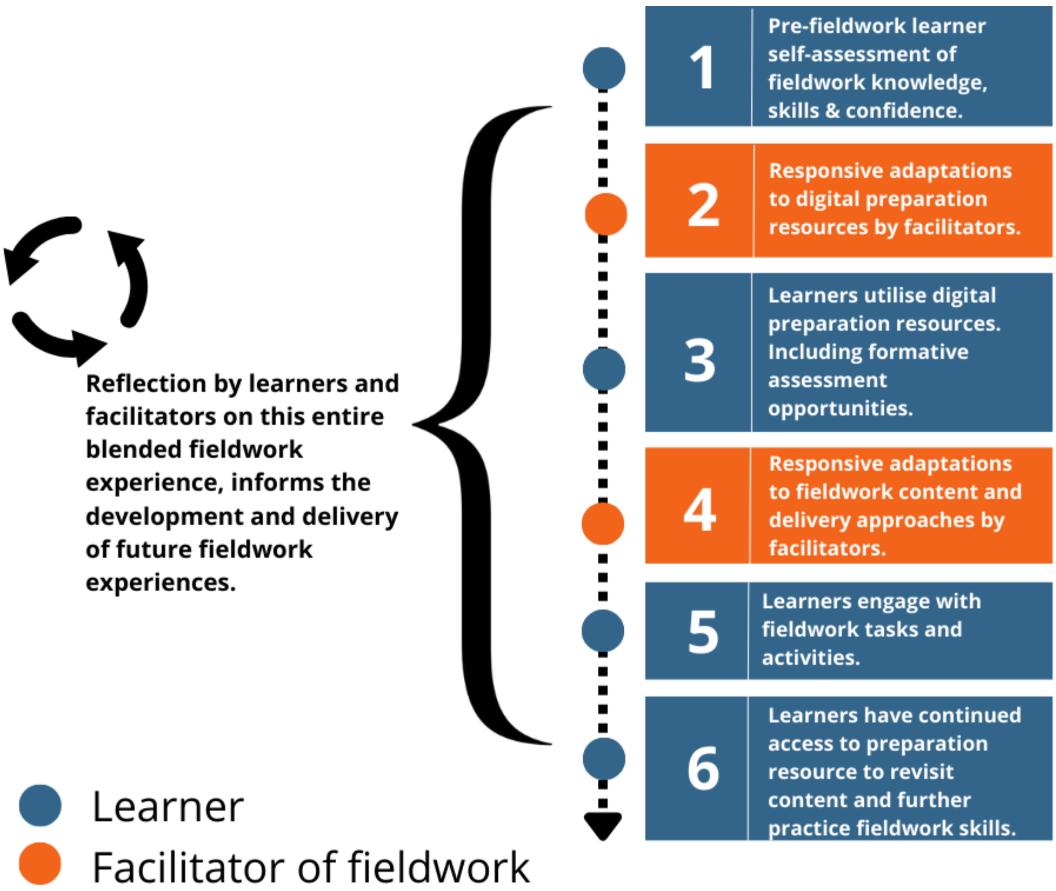

Figure 3.10 Emerging model of a blended learning environment for fieldwork. Learner (blue) and facilitator of fieldwork (orange) roles are illustrated.

3.6 Co-designed digital tools

3.6.1 Digital Field Notebook (DFN)

3.6.1.1 Digital Field Notebook (DFN) design brief

The DFN was designed to support students' notetaking in the field. The fieldwork challenge these resources were designed to address is the disconnect between fieldwork and classroom/lecture. They provided opportunities to foster students' personal connection to the fieldwork location and supported their connection to nature whilst developing subject specific digital skills and digital literacy.

The delivery mechanism of the DFN can be defined as using technology in the field. The pedagogic approach adopted was a student-led observation of the fieldwork environment using a mobile (m-fieldwork) approach.

The target audience for these resources were undergraduate and postgraduate bioscience students conducting fieldwork in unfamiliar fieldwork environments.

In summary, the tool collates fieldwork notes, spatially visualises them in real-time, and promotes a peer learning environment while enabling facilitators to review students' learning in the field. When evaluated through the lens of the SAMR model (Puentedura, 2013), the DFN represents a 'Modification', involving a substantial task redesign.

3.6.1.2 Digital Field Notebook (DFN) learning design and layout

The DFN developed as part of this research consisted of five pages (Table 3.10).

Table 3.10 Layout of the digital field notebook (DFN) survey hosted on ArcGIS Survey123.

Page	Content
1.	**Aims of survey and privacy notifications.**
2.	**Location of fieldwork** Users geo-locate their DFN entry. This can be achieved using locational capabilities of the mobile or tablet device. Alternatively, users can locate directly onto a base map. Users provide a place name (string entry).
3.	**Species identification** Common name (string entry). Confidence of identification (Single choice from 5-point scale) Habitat (Single choice from 10 options derived from Phase 1 Habitat classification). Photo of organism (Take photo or upload photo from camera roll) Description of organism to share any unique information about the organism, its behaviour or the habitat it has been found in (string entry).
4.	**Landscape interpretation:** Two prompts (string entry): Describe any patterns or features you can observe in the environment. Consider what physical processes and human impacts are having the biggest impact in this environment. Why?
5.	**Nature connection** Beauty: Users are asked to record three good things in nature that they can see in the environment (string entry). Meaning: Users are asked to reflect upon how the three food things in nature made them feel. (Single choice from 4 options derived from mood classification scales of high/low energy and positive/negative mood. Emotion: Users can then share something that has brought them joy and wonder at this fieldwork location (string entry).

Once students submitted DFN entries they automatically fed through into a DFN Dashboard (Figure 3.11), which displayed DFN data back to the user using geo-located symbols, bar charts, pie charts, photographs and text entries. The dashboard was fully interactive with the map extent filtering the data displayed in real-time.

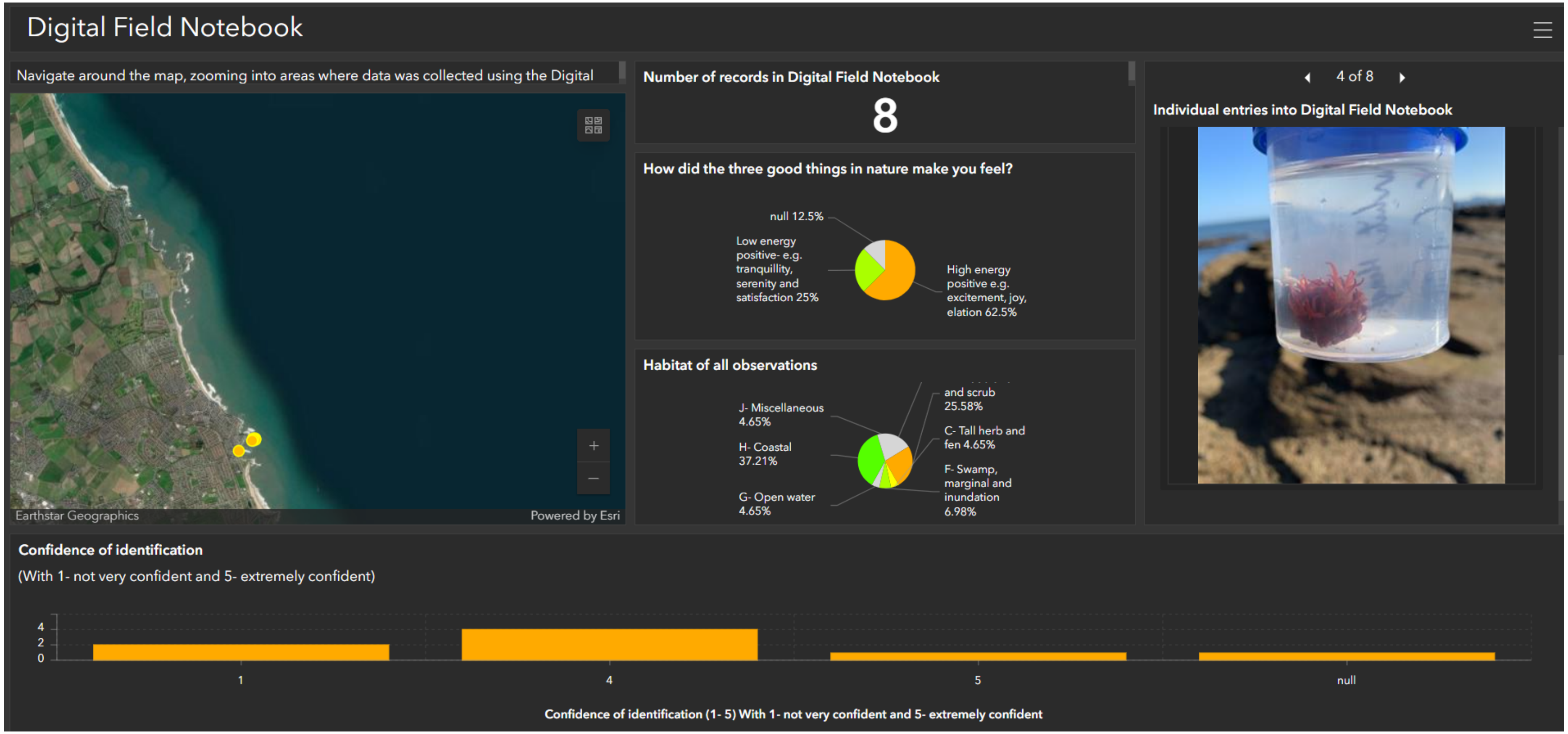

Figure 3.11 Excerpt of the interactive digital field notebook (DFN) data dashboard hosted by ArcGIS Dashboards. An interactive map filters dashboard data based on map extent.

3.6.1.3 Digital Field Notebook (DFN) EDI considerations

The DFN required students to use a mobile or tablet device with access to ArcGIS Survey123 app. Although a ‘Bring Your Own Device’ (BYOD) policy reduces resource implications for departments, facilitators cannot assume that all students have access to a mobile or tablet device or will be willing to use their own mobile device in the field. Having some institution owned devices available to use, encouraging pair or group DFN data collection and having universal waterproof cases available can reduce these issues.

Although the app collected DFN entries offline with collation of DFN entries possible when back online, reducing the requirement of students using their own mobile data in field; to enable in-field assessment and feedback by a facilitator, connecting to a network would be needed. Providing mobile signal is available, a pocket wireless dongle reduces students individual need to use their own mobile data.

All DFN entries were anonymous. All but the location questions were optional.

Inspired by the inclusive fieldwork design principles of Zavaleta *et al*. (2020), reflections by the author of the inclusion considerations of the DFN are summarised in Table 3.11.

Table 3.11 Inclusion considerations of the digital field notebook (DFN) to the five barriers (financial, information and knowledge, past opportunity, identity, commitment and personal circumstances) at three stages of fieldwork course design (plan, recruit/select, implement). Grey shading indicates where the DFN does not consider or address those barriers. These considerations were identified by reflections of the author.

		Stages of fieldwork course design		
		Plan	**Recruit/select**	**Implement**
Barriers that learners face for fieldwork inclusion.	**Financial.**	App with full offline function. App works on all mobile devices in field (personal devices, University supplied devices).		Supply of mobile devices and waterproof covers available.
	Information and knowledge.	Reflective questions within the app support recognition of learning across different domains of learning.		Designed to develop GIS skills.
	Past opportunity.			
	Identity.			
	Commitments & personal circumstances.			DFN supports a collated record of a field trip which can be revisited via the dashboard which includes geo-located photos, notes, reflections, and data.

3.6.1.4 Digital Field Notebook (DFN) assessment, collaboration and feedback

The DFN was designed to be inherently collaborative. Unlike traditional student field notes that are individually collected and rarely shared, DFN entries are digital at point of capture, collated together and automatically displayed back to students via the DFN dashboard. Using the DFN, students can view other students' identified species, fieldwork observations and personal reflections alongside their own.

Facilitators of fieldwork can review the DFN entries via the dashboard in real-time or after fieldwork. In reviewing the 'Confidence in ID' results, facilitators have a snapshot of a class's confidence in this skill area. Facilitators can address misconceptions that may have arisen in the fieldwork.

Providing students continue to add DFN entries, the DFN dashboard is ever-growing. The DFN can be used throughout all students' fieldwork experiences, with the DFN dashboard becoming a repository of a cohort of students' field notes throughout all their fieldwork experiences in HE. Facilitators of fieldwork can review entries to ensure whole cohort progression in species identification skills.

3.6.1.5 Digital Field Notebook (DFN) access to resources

The DFN is accessed via ArcGIS Survey123 (free app). To enable offline use of the DFN, students must download the ArcGIS Survey123 app when they are connected to internet. Once the app was downloaded, students were given a QR code which can be scanned on their mobile devices to access the DFN. Students could then download the DFN directly to the app, which enabled offline collection of DFN entries.

DFN entries were displayed back to the students via ArcGIS Dashboards, which were browser based and accessed via weblink.

3.6.1.6 Digital Field Notebook (DFN) logic model

A logic model was developed that illustrates graphically the link between resources, activities, outputs, and proposed outcomes of the DFN (Figure 3.12).

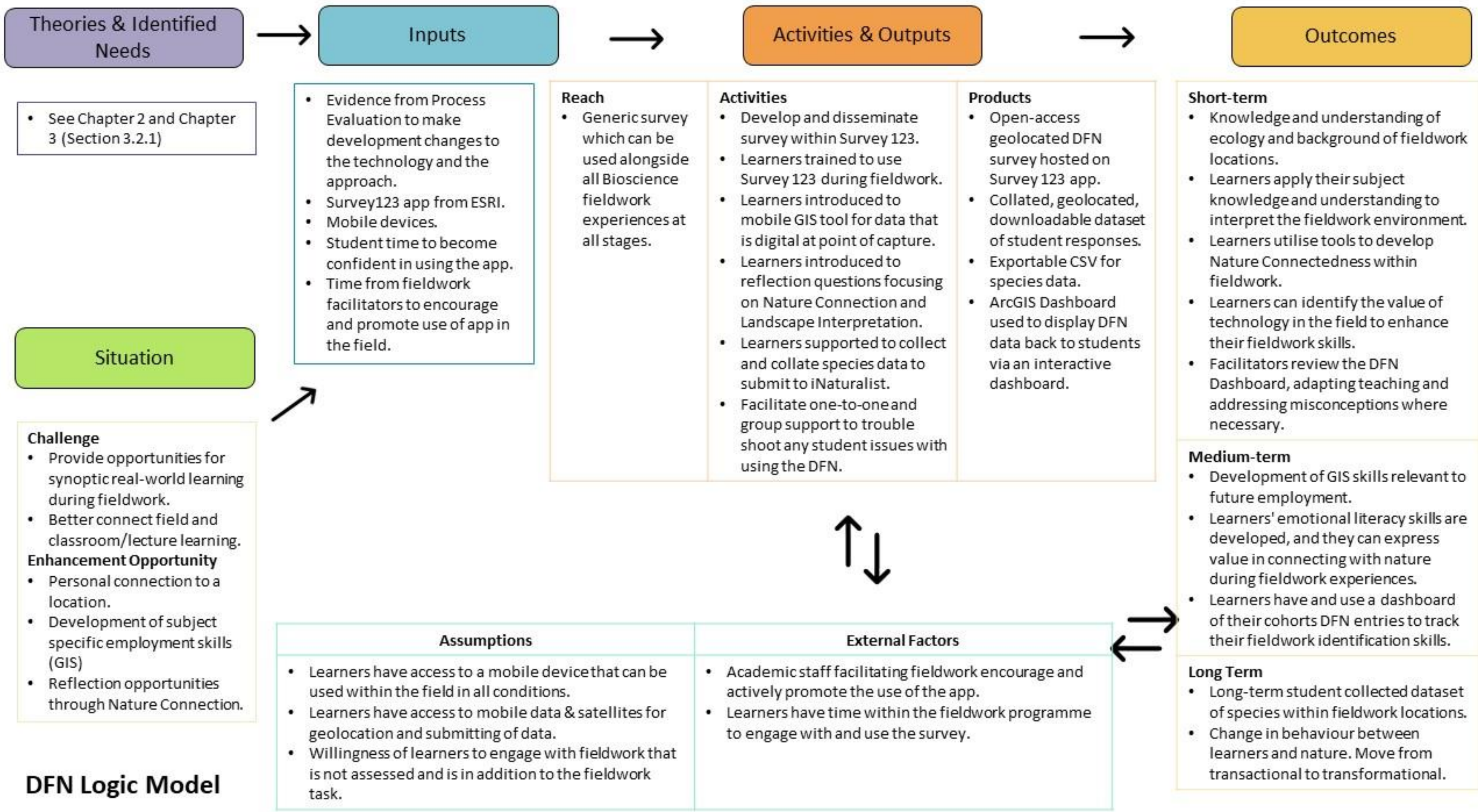

Figure 3.12 Logic model (using the 'Inputs, Activities, Outputs and Outcomes' template) for the digital field notebook (DFN). Key components and how they relate to each other are defined. This logic model is a graphical representation of how the DFN intends to produce its outcomes and address the challenge of a lack of connection between the field and the classroom.

3.6.2 Digital Preparation resources

3.6.2.1 Digital preparation design brief

The digital preparation resources are a tool to be accessed before students embark on residential fieldwork. The preparation resources are designed to address challenges that students may face associated with novelty of the fieldwork environment and a lack of confidence with fieldwork, with opportunities to promote student voice and advocate for differentiated support prior to fieldwork.

The delivery mechanism for the digital preparation resources can be defined as a blended, desk study, where students use digital resources to begin to develop knowledge, skills, and confidence to prepare them for their upcoming in-field fieldwork. The pedagogic approach adopted is a flipped learning approach with students using the digital preparation resources prior to embarking on in-field fieldwork to ensure there is a 'base level' of understanding of fieldwork knowledge, skills before applying those knowledge and skills in an in-field setting. This approach intends to build confidence before encountering the in-field fieldwork environment.

The target audience for these resources are students within the biosciences who were due to embark on their first residential fieldwork experience within HE.

In evaluating the digital preparation resources through a SAMR lens (Puentedura, 2013), the digital preparation resources if used in isolation represent an 'Augmentation', a direct substitute with functional improvement. However, if the digital preparation resources are used within the proposed blended learning environment for fieldwork (Figure 3.10) then the tool offers a 'Modification', with the technology allowing for a significant task re-design.

3.6.2.2 Digital preparation learning design and layout

Eight individual ArcGIS StoryMaps were collated into a collection; an overview document shared the title and overarching aim of each StoryMap (Figure 3.13).

Health & Safety	Develop an active understanding of the Health and Safety principles and practice that underpin fieldwork.	30-45 mins
Fieldwork Outcomes	Develop an understanding of the knowledge, skills and personal outcomes that can arise from fieldwork.	15-20 mins
Ethics in Fieldwork	Develop an understanding of ethics in fieldwork and how you can be an ethical researcher.	15-20 mins
Residential Fieldwork Experience	To understand the logistics, expectations and realities of undertaking residential fieldwork.	20-30 mins
Nature Connectedness	Develop an understanding of the benefits of being in nature.	15-20 mins
Why bother with fieldwork?	To explore a range of perspectives of why fieldwork matters?	20-30 mins
Equipment & Kit	An introduction to fieldwork equipment and personal kit you may need during fieldwork.	20-30 mins
The Role of Desk Studies	Consider the role of secondary research and sources of information to prepare for fieldwork.	30-35 mins

Figure 3.13 Overview document for the 'Preparing for fieldwork' resources. The title, overarching aim, and estimated time to complete resources for the eight StoryMaps included within the preparation resources.

Each individual StoryMap had specific objectives that students worked towards (Table 3.12).

Table 3.12 Objectives for the eight individual StoryMaps within the 'Preparing for fieldwork' resources.

StoryMap	Objectives
Health and Safety.	Describe the risk assessment process. Identify hazards present within a fieldwork environment. Explain hazard control measures that can be put into place to minimise the risks associated with a hazard. Apply dynamic risk assessment skills to fieldwork scenarios.
Fieldwork Outcomes.	Summarise the range of outcomes that can arise from fieldwork. Develop three individual SMART objectives as a focus for an upcoming fieldwork experience. Explain how these individual objectives will be met.
Thinking about ethics.	Describe what ethics means. Suggest methods of ensuring ethical principles are applied to fieldwork.
Why bother with fieldwork?	Summarise the importance of fieldwork in your subject. Explain how primary fieldwork data can be stored and utilised by others.
Residential fieldwork experience.	Describe a learner's roles and responsibilities whilst undertaking residential fieldwork. Gain an understanding of the fieldwork experience at a residential centre.
Nature Connectedness.	Describe the concept of Nature Connectedness. Identify three benefits of being immersed in nature and the outdoors. Summarise one method of increasing Nature Connectedness during fieldwork.
Kit and equipment.	Identify and explain the use of five pieces of fieldwork equipment. Adapt a kit list for your personal use on an upcoming residential field trip. Outline the role of notetaking during fieldwork.
The role of desk studies.	List three sources of secondary information that could be used.

	Identify three benefits of conducting secondary research prior to embarking on fieldwork. Demonstrate the ability to analyse two secondary sources of information to infer meaning about a fieldwork location.

3.6.2.3 Digital preparation EDI considerations

An ethos that underpinned these digital preparation resources was that they did not assume any knowledge, skills, or confidence of fieldwork in the students who had access to the resources. This promoted an inclusive approach to fieldwork.

Several sections of the preparation resource focused on specific EDI considerations; these included: personal fieldwork kit list, several videos that shared honest perspectives on what fieldwork is really like and information on periods during fieldwork.

Digital accessibility tools such as screen readers could be used on individual StoryMaps, closed captions could be included in all embedded videos and Alt-Text was provided for the images within the digital preparation resources. Unfortunately, the digital preparation resources were browser-based, therefore students did require access to the internet to use these digital tools. Inspired by the inclusive fieldwork design principles of Zavaleta *et al*., (2020), reflections by the author of the inclusion considerations of the digital preparation resources are summarised in Table 3.13.

Table 3.13 Inclusion considerations of the digital preparation resources to the five barriers (financial, information and knowledge, past opportunity, identity, commitment and personal circumstances) at three stages of fieldwork course design (plan, recruit/select, implement). Grey shading indicates where the digital preparation resources do not consider or address those barriers. These considerations were identified by reflections of the author.

		Stages of fieldwork course design		
		Plan	**Recruit/select**	**Implement**
Barriers that learners face for fieldwork inclusion.	**Financial**			
	Information and knowledge.			The resource supports learners to better prepare for fieldwork. Learners can choose what content is most appropriate to their individual circumstances. The content aims to level the playing field, to ensure that those learners without prior fieldwork experience are not at a disadvantage.
	Past opportunity.			
	Identity.	Specific focus on EDI within a section of the preparation resources titled- The Residential Fieldwork Experience enables learners to see the commitment	Diverse voices are sought within the design phase of the content through Youth Networks & Scholars programs at Field Studies Council.	Resource will undergo process evaluation prior to wider use. This will ensure co-design with participants forms a part of the iterative development of the resources.

		to EDI amongst the facilitators of the fieldwork.	Aim that the content features authentic student voice.	
	Commitments and personal circumstances.			Resource can be accessed asynchronously at any time by the learners. The resource will remain available during the field trip and available for future field trips.

3.6.2.4 Digital preparation assessment, collaboration and feedback

The digital preparation resources fit within an emerging model of a blended approach to fieldwork (Figure 3.10). This model opens pre-fieldwork lines of communication and feedback between facilitators and students. Assessment tasks within this model enable facilitators to conduct assessment for learning, making adaptations to support students individual learning needs. There were several tasks within the preparation resources that fostered peer collaboration via discussion boards.

3.6.2.5 Digital preparation access to resources

Despite the digital preparation resources using video, discussion forums, ArcGIS Online and ThingLink, they were all accessed via a single weblink. This weblink can easily be embedded within a range of learner management systems (LMS) e.g. Canvas and Blackboard. The resources work equally well on computers, tablet, and mobile devices. The collection can be duplicated from the master copy, meaning that facilitators of fieldwork can tailor the generic resources to suit specific fieldwork locations and contexts.

3.6.2.6 Digital preparation logic model

A logic model was developed that illustrates graphically the link between resources, activities, outputs, and proposed outcomes of the digital preparation resources (Figure 3.14).

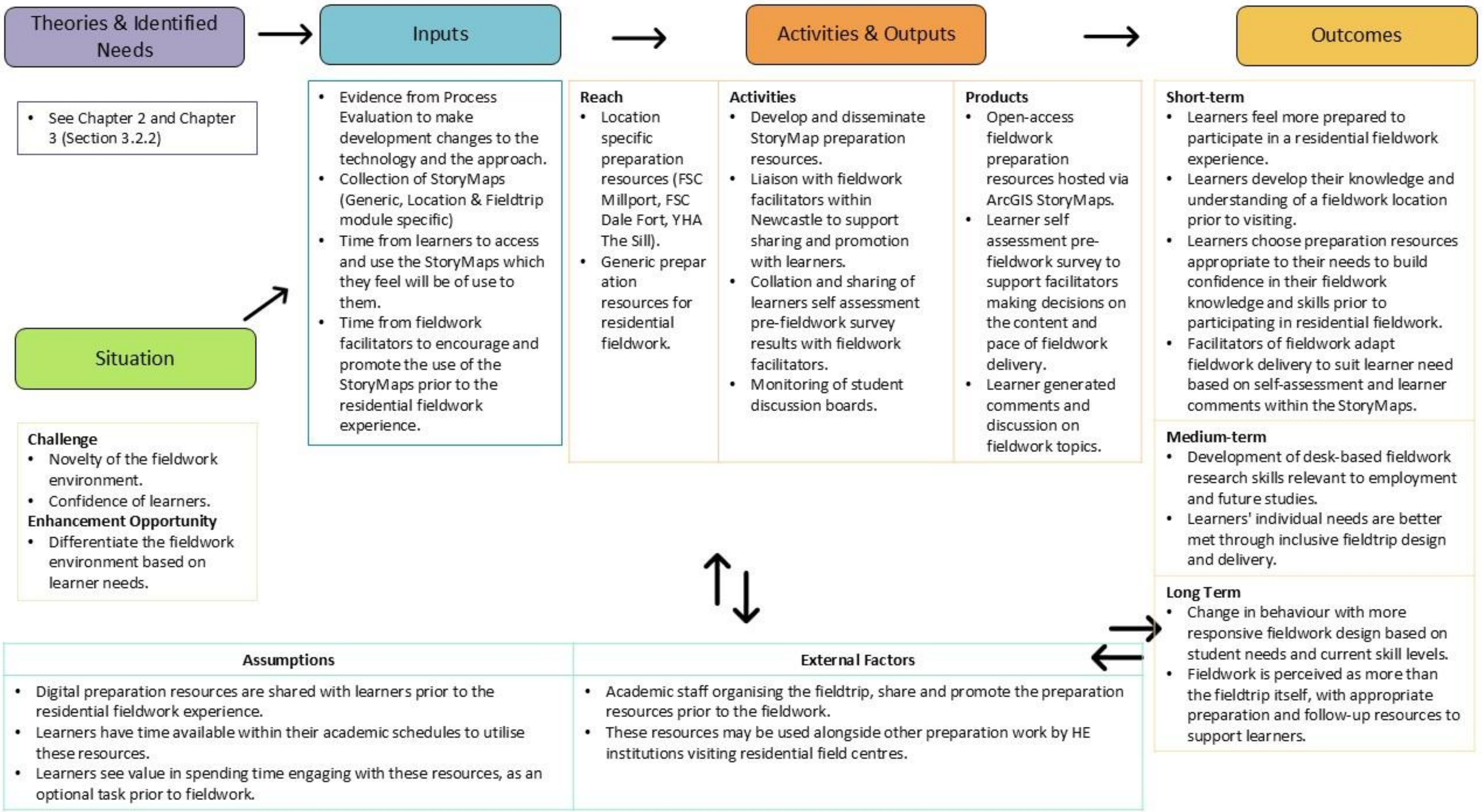

Figure 3.14 Logic model (using the 'Input, Activities, Outputs and Outcomes' template) for the digital preparation resources. Key components and how they relate to each other are defined. This logic model is a graphical representation of how the digital preparation resources intend to produce its outcomes and address the challenge of fieldwork novelty.

3.6.3 Virtual Field Trips (VFTs)

3.6.3.1 Virtual Field Trips (VFTs) design brief

The VFTs were designed to replicate fieldwork enquiries across three fieldwork locations. The fieldwork challenge these resources were designed to address was matching the pace of the fieldwork to students' progression in fieldwork skills, with opportunities for students to develop GIS skills and consider spatial comparisons across depositional environments.

The delivery mechanism of the VFTs can be defined as virtual asynchronous, where students engaged with authentic virtual simulation of fieldwork environments at a time and place of their choosing. The pedagogic approach adopted for the VFTs was a staff-led guided fieldwork enquiry.

The target audience for the VFTs was second year marine and ecology students within HE, with the guided fieldwork enquiries taking place in coastal depositional environments (sand dune and salt marsh) across Northumbria and Pembrokeshire, UK.

In evaluating the VFTs through a SAMR lens (Puentedura, 2013) the majority of the VFT offer an 'Augmentation', where they present a direct substitute with functional improvement. However, with the inclusion of the drone-captured replication of the sand-dune environment that offers a different perspective of this depositional environment, the VFT can be viewed as a 'Re-definition' where the technology allows for the creation of new tasks previously inconceivable.

3.6.3.2 Virtual Field Trips (VFTs) learning design and layout

Five individual ArcGIS StoryMaps were collated into a collection. An overview document shared the title and overarching aim of each StoryMap (Figure 3.15).

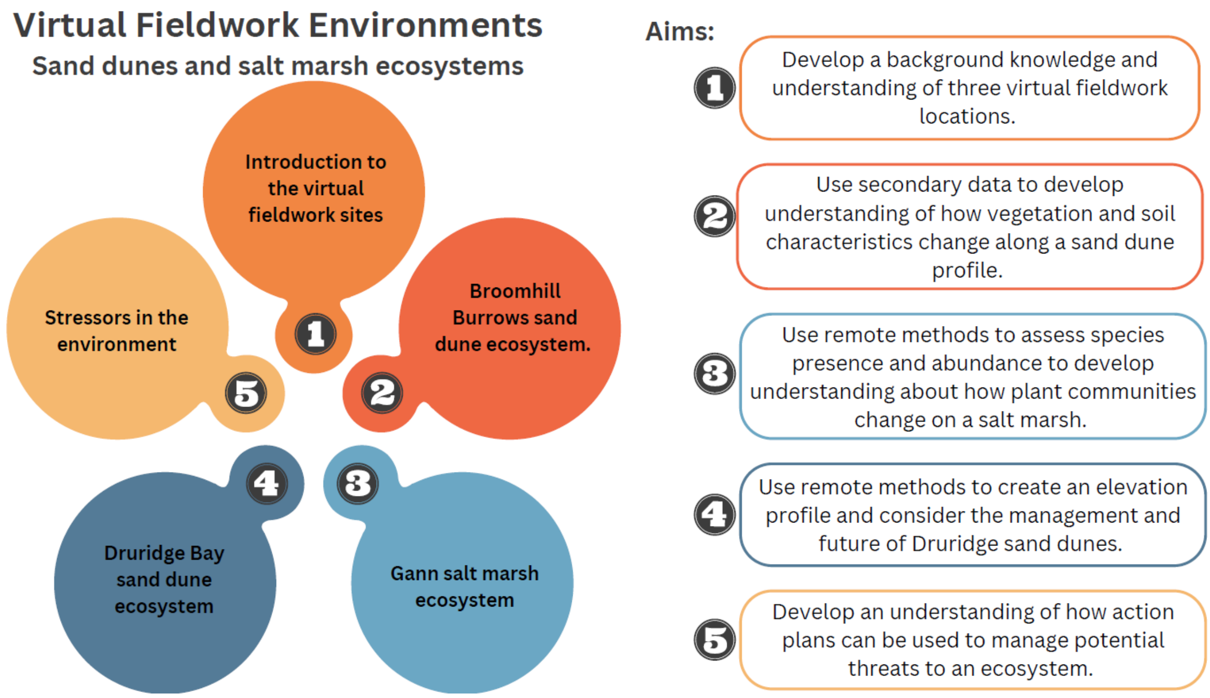

Figure 3.15 Overview document for the virtual field trips (VFTs). The title and overarching aim for the five StoryMaps which make up the VFT.

Each individual StoryMap had both objectives and tasks (Table 3.14). The guided fieldwork enquiry included the opportunity for students to develop a range of fieldwork skills such as species identification, landscape interpretation and species diversity calculations.

Table 3.14 Objectives and individual student tasks for the five StoryMaps within the Virtual Field Trips (VFTs).

	Objectives	**Tasks**
Introduction to the virtual fieldwork environments.	Demonstrate the ability to use and analyse secondary sources of information to infer meaning about fieldwork locations. Describe the process of creating a sketch map during fieldwork. Apply ecological understanding to a fieldwork location by observing and interpreting the landscape.	Task 1: Summarise your understanding about the two habitats (secondary sources). Task 2: Use the maps, aerial images, 360 photographs, species data and background information to explore the three locations. Task 3: Use the image of Druridge Bay sand dune ecosystem to create your own field sketch. Task 4: Use the question prompts to add any relevant additional annotations to your field sketch.

Broomhill Burrows sand dune ecosystem.	Justify the rationale for profiling a sand dune ecosystem. Calculate edaphic (soil) conditions along a sand dune transect. Use GIS tools to present and interpolate geospatial data on species richness on the sand dunes.	Task 1: List the key identifying features of buck's horn plantain, salad burnet and ribwort plantain. Task 2: Using the spreadsheet calculate vegetation and bare ground percentage cover for all remaining sites along the transect at Broomhill Burrows. Task 3: Using the spreadsheet calculate soil moisture and soil organic content for all remaining sites along the transect at Broomhill Burrows. Task 4: Describe and explain changes in the plant communities across the transect through the sand dune ecosystem at Broomhill Burrows, Pembrokeshire. Task 5: Assess the usefulness of a profile and soil analysis to support understanding of changes in plant communities across a transect in a sand dune ecosystem. Task 6: Explore the maps and data presented in the GIS. Task 7: How does the presence and abundance of two different species change across the sand dune system? Task 8: Describe the pattern of species richness across the sand dunes at Broomhill Burrows. Task 9: Suggest reasons for the spatial difference in species richness across the sand dunes at Broomhill Burrows.

Gann salt marsh ecosystem.	Use an ID key to identify a salt marsh plant species. Describe and explain the changes in the presence and abundance of plant species with increasing height above chart datum on the Gann salt marsh. Evaluate the use of percentage cover as a measure of plant abundance on the Gann salt marsh.	Task 1: Use the photos and the attached ID key to identify four plant species found on the Gann salt marsh. Task 2: Select a photo-quadrat at each height interval. Identify species present with the quadrat. Calculate percentage cover (%) of these individual species per quadrat. Task 3: Using the spreadsheet, choose eight species (+ bare ground) and enter the data observed from the photoquadrats to produce a kite histogram of your own data. Task 4: Describe and explain the changes in the presence and abundance of plant species with increasing height above chart datum. Task 5: To what extent is percentage cover using open quadrats an effective method to assess plant abundance on the Gann salt marsh.

Druridge Bay sand dune ecosystem.	Consider the role of drone surveys in assessing sand dune ecosystems. Use ArcGIS Scene and the 3D digital twin as a remote method to create an elevation profile across the sand dunes. Summarise the economic, environmental and social impacts of the proposed surface mine at Highthorn. Use ArcGIS Survey123 to share your views on the management and future of Druridge Bay.	Task 1: Watch the video of the drone survey and interact with the 3D model. What are the benefits of completing a drone survey of a fieldwork site? Task 2: Using the photoquadrats at each of the five distinct habitat areas. Calculate total percentage vegetation cover, percentage bare ground and species richness for each quadrat. Task 3: Use the drone captured digital twin to create an elevation profile of a transect through the sand dunes at Druridge Bay. Task 4: Using the four sources consider what are the social, economic and environmental impacts of the Highthorn surface mine proposal? Task 5: Share your views on the management of Druridge and the future of the site.
Stressors in the environment.	List three potential threats and three management strategies within sand dune environments. List three potential threats and three management strategies within salt marsh environments. Summarise stressors across the three fieldwork locations. Create an action plan to support the management of one of the fieldwork locations.	Task 1: Use your knowledge of the three fieldwork locations to construct a Venn diagram to compare the stressors impacting upon the three locations within this fieldwork enquiry. Task 2: For one of the locations, develop an action plan for the management of the site. Task 3: Save your action plan and upload to the discussion board. Look at other people's action plans. Add one comment and one question to another action plan.

3.6.3.3 Virtual Field Trips (VFTs) EDI considerations

The VFTs offered guided fieldwork enquiries located in Northumberland and Pembrokeshire, reducing the need to travel to these locations and the associated travel costs. For those students who due to physical disability needs, would have been unable to conduct fieldwork in a sand dune or salt marsh environment, the VFTs offered an immersive, practical fieldwork experience in these environments without the physical need to visit these fieldwork locations. Digital accessibility tools such as screen readers could be used on the individual StoryMaps, closed captions could be included in all embedded videos and Alt-Text was provided for the images within the VFTs. Unfortunately, as the VFTs were browser-based students do require access to the internet to use these digital tools. Inspired by the inclusive fieldwork design principles of Zavaleta *et al*., (2020), reflections by the author of the inclusion considerations of the VFTs are summarised in Table 3.15.

Table 3.15 Inclusion consideration of the Virtual Field Trips (VFTs) to the five barriers (financial, information and knowledge, past opportunity, identity, commitment and personal circumstances) at three stages of fieldwork course design (plan, recruit/select, implement). Grey shading indicates where the VFTs do not consider or address those barriers. These considerations were identified by reflections of the author.

		Stages of fieldwork course design		
		Plan	**Recruit/select**	**Implement**
Barriers that learners face for fieldwork inclusion.	**Financial.**	Resource is browser based, and works on all devices (mobile devices, tablet devices, laptops).		By broadening the delivery channel of fieldwork via virtual mode. The resources support learners through increased opportunities to develop their personal fieldwork skills with no cost for participation in the fieldwork.
	Information and knowledge.			The resource supports learners in providing additional opportunities to develop fieldwork knowledge and skills separate from the in-person fieldwork. Learners can revisit content and practice skills developing their confidence in fieldwork at a pace directed by themselves.
	Past opportunity.	Content of the resources means that learners can use this resource pre, post or independent of in-person fieldwork taking place in the same environment. Learners can		

		make a decision of when to access and use these resources dependent on their individual circumstances and fieldwork knowledge and skills.		
	Identity.			Resource will undergo process evaluation prior to wider use. This will ensure co-design with participants forms a part of the iterative development of the resources.
	Commitments and personal circumstances.	Valid alternative for some of the in-person fieldwork within Field Weeks. Learning Outcomes matched/referenced from in-person fieldwork options as part of the module.		Resource can be accessed asynchronously at any time by the learners.

3.6.3.4 Virtual Field Trips (VFTs) assessment, collaboration and feedback

Many of the tasks such as the field sketch, analysis and discussion question prompts will result in student outputs that could be submitted for formative assessment. Additionally, the production of the site action plan for the management of one of the sites was an example of an authentic assessment. Despite the VFTs being designed to be accessed asynchronously, there were several tasks within the VFTs that encouraged collaboration between students. Students could share their views on the future of one of the fieldwork sites, with all views inputted shared back to students. Students were asked to upload these to a digital whiteboard to share their action plans with their peers. A specific task encouraged students to add a comment and question to another students' action plan.

3.6.3.5 Virtual Field Trips (VFTs) access to resources

Despite the VFTs using a range of digital tools (ThingLink, ArcGIS Scene, ArcGIS Online, Survey123, Padlet, Microsoft Excel), ArcGIS StoryMaps hosts all of these digital tools into one weblink. This weblink could easily be embedded within a range of LMS e.g. Canvas and Blackboard. The VFTs worked equally well on computers, tablet, and mobile devices. The collection can be duplicated from a master copy.

3.6.3.6 Virtual Field Trips (VFTs) logic model

A logic model was developed that illustrates graphically the link between resources, activities, outputs, and proposed outcomes of the VFTs (Figure 3.16).

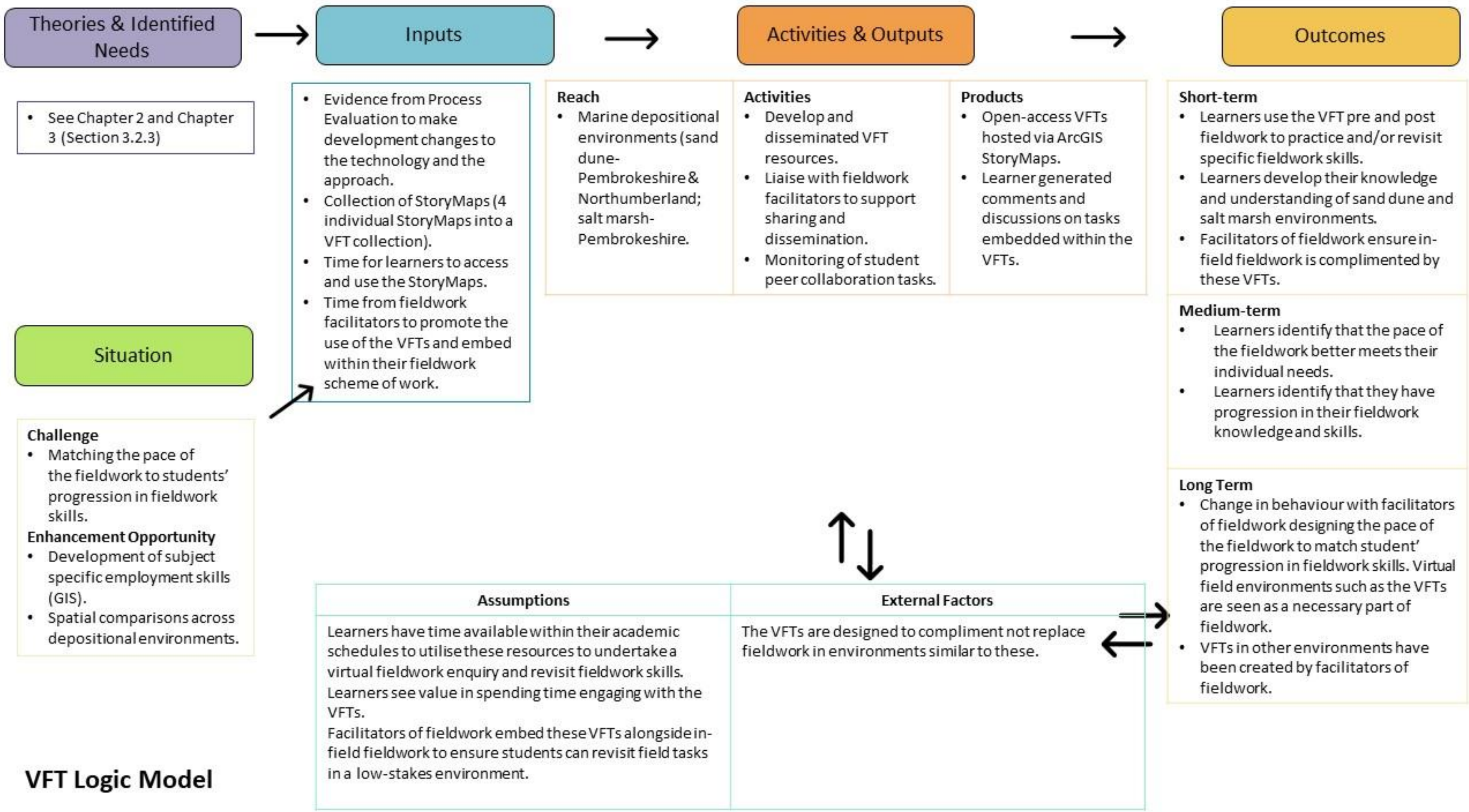

Figure 3.16 Logic model (using the 'Inputs, Activities, Outputs and Outcomes' template) for the Virtual Field Trips (VFTs). Key components and how they relate to each other are defined. This logic model is a graphical representation of how the VFTs intent to produce its outcomes and address the challenge of pace and progression in fieldwork.

3.7 Discussion

This research presents an approach for using student voice in the development of digital fieldwork approaches, by working with students in a co-design process to develop three digital tools. These digital tools (DFN, digital preparation resources and VFTs) underwent a process evaluation to uncover the student experience of using the digital tools and their underlying understanding of the purpose of the digital tool. Feedback on the digital tool was sought, with areas for development identified and implemented before the three digital tools were presented in this chapter.

Students who trialed the resources suggested content, technology, and pedagogy developments that they believed would improve the experience of using each of the digital tools within fieldwork. This contrasts with another co-creation study whereby students could critique digital, and technology enhanced learning within HE, but struggled in suggesting their own ideas (Gros and López, 2016). Allowing learners space and time for free-form exploration has been recognised as enabling 'spontaneous development' where learners found alternative or more effective ways of using mobile apps within fieldwork (France *et al*., 2016). The testing phase and student as partners approach within this current research offered this free-form exploration. Students identified several developments that would enhance the use of each of the digital tools e.g. use of a single map to enable peer collaboration via the collation of DFN entries, inclusion of real-world experts to showcase value of fieldwork in the digital preparation resources and inclusion of formative assessment and VR opportunities within the VFTs to support learner engagement with the VFTs.

It has been recognised that during the co-creation process of developing technology enhanced learning, co-creators can default to traditional roles of teacher as expert and student as novice; with teachers not honoring student voice within the co-creation process (Gros and López, 2016). The combination of using responsive feedback mechanisms (Viswanath *et al*., 2019) within this current research, and a postgraduate researcher facilitating this co-creation process, it may have enabled student experiences and suggestions for improvement to be valued and incorporated within the redesign. With this fostering the student as partners approach, where students' trial the tools before giving feedback, student voice feedback was honoured and incorporated into the developments. Although not surprising, it does emphasise the value in working with students and valuing student voice during the development process of digital tools in fieldwork.

One of the tools developed, digital preparation resources, are now embedded within an emerging model of a blended fieldwork approach presented within this research. Six stages of fieldwork were defined with identified touchpoints between learners and facilitators of fieldwork via formative assessment and self-assessment tools. Although three main phases of a field trip have been identified within the literature with the associated tasks (1. Before: pre-fieldwork tasks to prepare; 2. Fieldwork: task orientated fieldwork data collection; 3. After: post-fieldwork outcome focused analysis and review of data) (Morag and Tal, 2012), the model of blended learning presented within this research (Figure 3.10) provides further detail to this first identified pre-fieldwork phase. Students desire increased opportunities for communication facilitated by digital tools between themselves and facilitators throughout this stage, with increased opportunities for learners and facilitators to act upon this information within the embedded formative assessment opportunities and inform future stages.

Although other models of blended field trips that incorporate online learning and in-field components can be found within the literature (Durrant and Hartman, 2015; Geange *et al*., 2021; Nicotra *et al*., 2022; Wallgrün *et al*., 2022; Oktavianto *et al*., 2023; Husby *et al*., 2024), many of these lack information on the roles of facilitators and learners in constructing the blended fieldwork environment (Durrant and Hartman, 2015; Geange *et al*., 2021; Nicotra *et al*., 2022; Wallgrün *et al*., 2022; Husby *et al*. 2024) or lack information on the transition between different phases of fieldwork (Oktavianto *et al*., 2023; Husby *et al*., 2024). The model emerging in this research is unique as it provides a process for facilitators to embed a blended learning environment for fieldwork by providing explicit detail on roles and tasks for both learners and facilitators of fieldwork; and how the different components of the blended fieldwork environment interact and inform each other. The reflective cycles present within the model, support the application of the experiential learning cycle (Kolb, 2015) to biosciences fieldwork in HE, extending existing work (Healey and Jenkins, 2000; Krakowka, 2012; Scott *et al.*, 2012; Burden, 2017; McPhee, 2021).

Many studies recommend that preparation is key to support neurodiverse learners in fieldwork (Lang and Persico 2019; Kingsbury *et al*., 2020; Taylor and Johnson, 2020) yet there are little examples within the literature of what this preparation should contain or how learners should engage with it, although students have identified that digital resources are useful in preparing for fieldwork (Wallgrün *et al*., 2022). The digital preparation resources co-developed with students in this research present a method of using a digital approach to provide familiarisation and skill development prior to undertaking fieldwork, and like other digital fieldwork tools add value pre-fieldwork (Horota *et al*., 2023). Learners can often experience increased stress and anxiety during field courses (Woodley *et al*., 2024), and this blended fieldwork approach offers an approach to better support these learners.

Additionally, based on student feedback, increased opportunities for active learning via peer-to-peer collaboration were included in the re-developments. Co-operative learning activities are a best practice component of virtual fieldwork environments (Klemm and Tuthill, 2003) with collaborative activities recommended in the virtual world (Lee, 2009; Šašinka *et al*., 2019; Hutchinson *et al*., 2024). This communication between facilitator and learner, and the increased interaction between peers within the digital preparation resources helps to maintain a focus collaboration and support preventing issues with learner independence during digital fieldwork (Ruan *et al*., 2021) and is more akin to the decision-making opportunities learners encounter during fieldwork which are often missing from linear VFTs (Peace *et al*., 2021).

The VFTs were the digital tool that students identified the most skill development opportunities within; many of which were the same skills that learners have identified as developed during residential fieldwork (Peasland *et al.*, 2019) and in other virtual field environments (Mead *et al*., 2019) and is a key benefit of virtual field environments (Cliffe, 2017). It shows that students in the user-testing identify the potential for VFTs to complement existing fieldwork practice through improving access of opportunity to fieldwork and accessibility of fieldwork by replicating fieldwork tasks seen in other VFT studies (Cowles and Onthank, 2021; Jeffery *et al*., 2021; Hutchinson *et al*., 2024). However, students in the testing group identified four other purposes of the VFTs including their use pre-fieldwork as preparation and post-fieldwork as a revision tool. This presents a potential scenario where learners may lack clarity on the intended use of the VFT alongside their existing fieldwork. The learner perception of a blended environment is integral to its integration (Moore and Gilmartin, 2009).

Students identified that the DFN offered opportunities to develop fieldwork observation skills and personal attribute skills such as self-reflection and critical thinking. Interestingly, however, the students did not recognise skill development related to the location-based functions of the DFN. Other mobile apps with location-based functions have been identified as supporting spatial thinking and spatial relationships in geography, earth, and environmental science (GEES) disciplines (Senger and Nordmo, 2021; Xie *et al*., 2021). So, although the DFN presents the potential for spatial interrogation of fieldwork data within a bioscience context (Maddison *et al*., 2023a) this was not realised by students within the trial group and warrants further exploration.

Although feedback and the resulting developments from this process evaluation can be used to address issues students may face when using the three digital tools, barriers to their use remain. Within this research a complex narrative surrounding how students view the use of technology in the field emerges. Ease of use, permission to use and hesitancy to use are all identified facets of this. Suggestions for overcoming the human perception barrier to using technology include the use of simple technology that is seamlessly integrated (Welsh *et al*., 2013). Although students identified that the DFN was easy to use, the barriers and willingness to use a mobile device during fieldwork remained an issue for students. This was not identified as being an issue with the durability of the mobile device itself or data issues which have been identified elsewhere (Ruan *et al*., 2021), but rather the environmental conditions making using the mobile device challenging. Similar findings of using a DFN in polar conditions were identified (Senger and Nordmo, 2021). Although seemingly trivial, cold fingers were identified as an issue for students using this DFN during a less extreme UK environment of fieldwork in winter months, when some of this research occurred.

Students trialing the use of the DFN commented on their lack of awareness of a mobile device as a learning tool. While able to identify pedagogic benefits of using the DFN, they had reservations about using it based on their previous educational experiences with technology. This is supported by other research which found that learners did not recognise pedagogic value of mobile devices for fieldwork (Welsh *et al*., 2015). This is in direct contrast to studies that have found that learners view digital fieldwork apps as useful (Arrasyid *et al*., 2024) and that technology is an extension to the scientific tools they were already using (Huffling *et al*., 2014)

Additionally, students shared a hesitancy to use mobile devices in education settings, based on real or anticipated reactions of the facilitators of fieldwork and the expected norms of mobile device use in educational settings.

3.8 Limitations

The limitations of the content analysis conducted in this chapter are previously outlined in section 2.5. However, in using relevant established frameworks for the deductive content analysis, such as the skills framework (Peasland *et al*., 2019) and TPACK framework (Koehler and Mishra, 2005; Voogt *et al*., 2013), this has enabled comparability of the findings within this research with other studies, enhancing the validity of the findings within this chapter.

Despite the VFTs and the digital preparation being well received by students and all three of the tools providing skill development opportunities for students, what emerges from this research are findings that identify that students are unfamiliar with technology use in fieldwork and lack clarity on the purpose and value of some digital tools in fieldwork. Despite addressing some of these issues within the developments, this is an ongoing barrier to the effective integration of digital tools in fieldwork and something which warrants further research and consideration.

Although the user testing was an in-depth process where the researcher worked with students to uncover their experience of the challenges, experience of using the tools and their suggested improvements, this user testing of each of the tools was completed with a very small testing group (DFN n = 7; digital preparation resources n = 6; VFTs n = 6) and is not therefore a representative view of the learner experience of using these tools. A larger group of learners (e.g. the entire cohort) could have been given access to the digital resources, with an online evaluation of the digital tool administered. While fatigue with education evaluations, often influenced by over-surveying of HE learners can lead to survey non-response (Porter *et al*., 2004), it has been found that interest in participating in evaluations is higher in courses that learners are enrolled in and actively contributing to their academic community (Adams *et al*., 2012). This academic community component could have been capitalised on during the fieldwork experience, where learners traditionally build strong relationships with facilitators of fieldwork (Glackin, 2018), their peers (Walsh *et al*., 2014) and build communities of practice (Streule and Craig, 2016).

This research incorporates student voice in the development and integration of digital tools in fieldwork. However, a missed opportunity is in considering the impact on students of participating in this consulting role. Studies that have sought to capture student perspectives of participating in co-design processes have found benefits to those participating, identifying they had more awareness of teacher and learner roles (Garcia *et al*., 2018), realised benefits of working collaboratively (Prescott *et al*., 2020; Woods and Homer, 2022) and identified the development of transferable graduate skills (Pauli-Hones *et al*., 2016). The level of partnership adopted meant that the student user testing groups trialed and evaluated a MVP version of each of the digital tools before offering feedback and development suggestions. These MVPs were informed by findings within Chapter 2, which worked with a different group of students (n = 22), with the researcher designing the MVPs and undertaking the developments identified within this research. An alternative approach would involve a more invested SaP approach which would use students to design the tools themselves, rather than informing the design and suggesting developments. This would involve a more substantial investment in time and commitment by the students.

Although the user testing of the VFTs was conducted with student users from six different HE institutions, the user-testing of the DFN and digital preparation resources was undertaken with students from a single UK HE institution. So, their experiences may not represent the broader experiences of learners across other institutions. It would be useful to consider how the digital tools could translate into other contexts and be incorporated into other institutions, with a process to capture learnings and inform continual iterative developments based on these translations.

3.9 Summary

Informed by the work of Chapter 2, three digital tools were co-designed with students to address a specific pedagogic challenge. Firstly, a DFN to address the disconnect between fieldwork and the classroom. Secondly, digital preparation resources to address challenges associated with the novelty of the fieldwork environment. Finally, VFTs to support an appropriate pace of fieldwork and progression of fieldwork skills. Each of these digital tools underwent user-testing with a MVP version of the tool shared with a small group of students. These students gave feedback on the tool and suggested technology, content, and pedagogy developments to improve each of the tool. Student feedback was also used to exemplify the TPACK framework to support the integration of technology.

Chapter 4. Co-producing a Live Fieldwork Broadcast in the Biosciences

Abstract

Most live broadcast work in education operates with an expert to novice delivery mode, and in indoor settings such as surgical teaching environments. Those few examples of live broadcasts from outdoor locations have heavy resource requirements, limiting their uptake within Higher Education (HE). Working with undergraduates, this research aims to test the feasibility of a low-cost and low-tech solution to produce a live fieldwork broadcast within the biosciences. The co-production partnership successfully produced a live broadcast from conception to delivery in 2022-2023 with three placement students and in 2023-2024 with two placement students and three mentors. A pocket wireless modem created an outdoor wireless network with a mobile device and wireless microphones used to deliver the broadcast. Semi-structured interviews and a reflective researcher diary explored the impact of this approach to co-produce a live fieldwork broadcast. Enjoyable aspects of the placement identified the opportunity for new experiences and sense of achievement. The live fieldwork broadcast placement enabled the placement students to develop 34 skills, with 88% of skills identified by at least one student. Most skills developed were transferable including teamwork and project planning. The simple and low-cost technology used provides a solution to address the barriers of technology integration within fieldwork and offers insight into the experience of working in partnership during a live fieldwork broadcast.

4.1 Introduction

4.1.1 Live broadcasting in education

Live broadcasting or livestreaming or live video streaming involves a real-time transmission of information over the internet, with some form of interaction with the host/presenter and/or between users (Lv *et al*., 2022) or with embedded polls (Wang and Li, 2020) to enhance the experience. It is intended for consumption by the public and often accessed via social media (e.g., YouTube Live, Facebook Live) (Rogers, 2023). Its use in Higher Education (HE) institutions is well documented with implementation in surgical teaching (Williams *et al.*, 2011; Brandt, 2020;

Fang *et al*., 2022), dental teaching (Iwaki *et al*., 2013; Wang *et al*., 2021b), development of English-speaking skills (Shen *et al*., 2008; ChanLin, 2020), film studies (Robert and Lenz, 2009), and nutrition education programmes (Adedokun *et al*., 2020). Justification for the use and benefits of live broadcasting include access to broader audiences (Walker-Cook, 2019; Obenson, 2021), enhanced views via multiple camera feeds (Iwaki *et al*., 2013; Brandt, 2020), providing a comfortable clinical teaching environment (Fang *et al*., 2022) and as a solution for remote teaching during Covid-19 pandemic (Yu *et al*., 2021; Stagg *et al*., 2022).

4.1.2 Taking live broadcasting outdoors

The majority of these education live broadcasts involve indoor spaces with wireless internet, and specialist recording technologies (Williams *et al*., 2011; Iwaki *et al*., 2013; Fang *et al*., 2022). Although broadcasting indoors is not without challenges (e.g., requirement to sterilise audio-visual equipment in surgical settings (Brandt, 2020)), live broadcasting outdoors has its own unique set of challenges including the need for portable equipment (Robert and Lenz, 2009) that can withstand the environmental conditions of the site and the ability to set up a wireless network (Cassady *et al*., 2008). Whilst this can be addressed via the use of (Wireless) Local Area Network ((W)LAN) in a field setting (Whitmeyer *et al*., 2020) or the use of satellite systems (Robert and Lenz, 2009), many of these adaptations require a digital technology field expert and/or specialist outdoor recording equipment (Marshall *et al*., 2022), meaning cost, skills and capacity to invest the time in this, which can present a barrier for wider adoption of using digital technologies in fieldwork (Fletcher *et al*., 2007; Thomas and Munge, 2017; Clark *et al*., 2020).

Live fieldwork broadcasts have become a regular occurrence for the Open University's fieldwork teaching to its online learner population (FieldCasts) (Open University, 2023; Brown *et al*., 2023) yet their use in a more typical university biosciences fieldwork setting without specialist technology support is limited. In-field mobile technologies have been used to support inclusion and access to field courses for learners who might traditionally be excluded from participating (Atchison *et al*., 2019; Marshall *et al*., 2022). They were also implemented as a response to restrictions to fieldwork and the outdoors during the Covid-19 pandemic (Stagg *et al*., 2022). The large audience (almost 400,000 registered) of the geography and science #FieldworkLive program from Field Studies Council (FSC) suggests an appetite for live broadcast delivery modes across education sectors to access fieldwork learning (Stagg *et al*., 2022). Although the context of restrictions to outdoor spaces and UK school/university closures during this time likely influenced this high audience uptake. Post pandemic studies of live fieldwork broadcasts are required to firstly, develop an understanding of the value and experience of adopting live streaming technologies to deliver fieldwork content without Covid-19 restrictions limiting access to fieldwork environments. Secondly. whether live broadcasting could better connect teaching and fieldwork practice via the development of a research-teaching nexus (Griffiths, 2004) and finally offer a solution to some of the identified challenges of current fieldwork practice in HE such as sustainability issues of overseas fieldtrips and access issues for students who work and/or with caring responsibilities (Woodley *et al*., 2024).

Although the specific functions and affordances of live broadcast in education are documented (Williams *et al*., 2011; Iwaki *et al*., 2013; Walker-Cook, 2019; Brandt, 2020; Obenson, 2021; Fang *et al*., 2022), the research of live broadcast in fieldwork education is more limited (Stagg *et al*., 2022; Brown *et al*., 2023). With the future role of live fieldwork broadcast in outdoor fieldwork settings is undocumented, this research contributes to furthering our knowledge on the role of students co-producing their own live fieldwork broadcast within the biosciences and the impact on them of doing so, as well as offering their perspectives on the potential of live broadcasting within fieldwork education in the future.

4.1.3 Involving student in live broadcasting in education

The advancements in low-cost recording and broadcast technologies have led some to recognise the potential for creative and interesting user-generated video content (Laaser and Toloza, 2017), with the unique role that a student facilitator can play in promoting peer discussion during live broadcasting (ChanLin, 2020). However, much of the content of live broadcast within education can be defined as ‘explainer’ style videos (Kulgemeyer, 2020) with expert delivery to a novice audience (Williams *et al*., 2011; Iwaki *et al*., 2013; Brandt, 2020; Wang *et al*., 2021b; Fang *et al*., 2022; Stagg *et al*., 2022).

The Open University’s FieldCasts offer actively encourages participation and promotes learner decision-making during these fieldwork broadcasts (Open University, 2023). During the live broadcasts presenters adopt a range of roles which support learners throughout the fieldwork enquiries by guiding their thoughts, promoting engagement, encouraging participation, and developing a sense of belonging (Brown *et al.*, 2023). Yet despite guiding the fieldwork decision-making process, the learners are still in an audience role rather than as a co-creator of knowledge. Recognising that bioscience learners' employability skills are developed during placement opportunities (Hejmadj *et al*., 2012) and inspired by a youth-led live broadcast 'Nattering with the NHS' where learners identify employability options with the NHS (Reeves *et al*., 2022), this research will evaluate the impact on students of participating in the creation and delivery of a live fieldwork broadcast via an employability placement. It will test the feasibility of a low-cost solution to network and broadcast from a field environment that does not require expert knowledge, or specialist skills to operate. Drawing upon the 'Students as Partners' (SaP) framework (Healey *et al*., 2014), and the call for attention to uncovering the challenges, opportunities and benefits in developing partnership learning communities (Healey *et al*., 2016) this research explores the meaning of partnership within the context of co-producing a live biosciences fieldwork broadcast with undergraduate students, considers the emotions and attitudes of those working in partnership throughout the live fieldwork broadcast and identifies the skills developed throughout the process.

4.1.4 Research aim and objectives

The overarching research aim (RA) of this chapter is to explore the impact of working in a partnership with students to deliver fieldwork using live broadcast methods (RA3). To address this aim, this chapter will focus on five research objectives (RO). First, it will test the feasibility of a low-cost and low-tech solution to network the fieldwork environment for the production of a live broadcast (RO3.1). Second, it will describe the emotions and attitudes of those working in partnership to co-produce a live fieldwork broadcast (RO3.2). Third, it will identify the impact of participating in the live fieldwork broadcast placement (RO3.3). Fourth, it will explore the meaning of partnership during the co-production of a live fieldwork broadcast (RO3.4). Finally, it will consider the future role of live broadcast in fieldwork education (RO3.5).

4.2 Context underpinning the research

All second-year undergraduates on marine science degrees within Newcastle University participate in a 35-hour work placement as part of a Research and Employability Skills module. The aim of these is for placement students to carry out a task or project relating to research, development, or communication in marine science on behalf of their placement provider, in order to enhance their employability upon graduation. In total 24 different placement providers offered placements to students in 2022-2023 with 23 placement providers in 2023-2024.

Students were provided with short placement briefs written by the providers. Students applied directly to placement providers with Curriculum Vitae (CV) and covering letters. Some placement providers interviewed applicants to select placement students. Three live fieldwork broadcast placements were offered in both 2022-2023 and 2023-2024, with the placement brief provided to all students (Table 4.1) alongside participant information about the research project. Participation in the research project was not a pre-requisite for undertaking the live fieldwork broadcast placement.

Table 4.1 Live fieldwork broadcast placement brief. Key features of the placement are in bold.

Live fieldwork broadcast- placement brief
This placement provides an opportunity to work on an **educational development** project. It will include using **science communication** and **public engagement** skills alongside developing competencies in using **digital broadcast tools**. The aim of the placement is to **design**, **develop** and **deliver** a Fieldwork Live Broadcast with placement students working in **partnership** with a PhD researcher to co-design the content of the live broadcast and deliver the final live broadcast to its intended audience.

The live fieldwork broadcast 35-hour placement ran over nine weeks within an academic semester. In the 2022-2023 cycle, three students accepted the live fieldwork broadcast placement. In the 2023-2024 cycle, two students accepted the live fieldwork broadcast placement. During the 2023-2024 cycle, the placement students from the 2022-2023 cycle were offered a paid mentoring role within the partnership. All three 2022-2023 placement students accepted this role and were employed in a peer-mentor role for 8-10 hours each. Table 4.2 defines the mentoring role that these students performed during the 2023-2024 cycle.

Table 4.2 Information on the paid mentor roles that the 2022-2023 placement students performed to support the 2023-2024 placement students.

Focus	**Hours**
Meet with 2023-2024 placement students. Share experience of 2022-2023 placement. Answer questions from 2023-2024 placement students.	1
Individual preparation/mentoring based on responsibilities.	2
Individual preparation/mentoring based on responsibilities.	1-3
Live event: Individual responsibilities: - Presenter. - Presenter and moderation of audience interaction. - Live producer assistant.	4

Participation in the research was voluntary, and all participants provided informed consent in line with the ethical approval granted by the School of Natural and Environmental Sciences at the researcher's university (Ref: 26538/2022).

Table 4.3 summarises the schedule for the placement. Sessions were arranged in advance, considering student academic timetables and other commitments.

In the 2022-2023 cycle, most sessions were held in-person, with all placement students on this placement in attendance. There were three sessions (5, 6, 11, Table 4.3) where placement students had the opportunity to work independently during asynchronous remote sessions, although support from the placement provider was available in-person or via Microsoft Teams. Two out of the three students scheduled in-person time with the placement provider during sessions 5 and 11.

In the 2023-2024 cycle, alongside the scheduled in-person and asynchronous remote sessions; several synchronous remote sessions were scheduled. This offered a more realistic model of a hybrid work environment for the placement students.

Table 4.3 Placement schedule for 2022-2023 and 2023-2024 live fieldwork broadcast placement. Shading of the cells refers to the delivery mode of the session (white = in-person session, grey = synchronous remote session and blue = asynchronous remote working).

	2022-2023	**2023-2024**
Session 1.	Onboarding to the placement. Review of existing live broadcasts. Idea generation to determine theme. Webpage development for promoting live broadcast.	
Session 2.	Storyboarding content for the live broadcast.	
Session 3.	1-2-1s.	1-2-1s.
Session 4.	Developing educational content.	Marketing and liaison with external colleagues.
Session 5.	Liaising with external colleagues.	Individual task work.
Session 6.	Developing educational content.	Individual task work.
Session 7.	Engagement, delivery and communication skill training with Field Studies Council (FSC) including introduction to Open Broadcaster Software Studio (OBS Studio).	Engagement, delivery and communication skill training with FSC.
Session 8.	Trial of technology for live broadcast (wireless network and wireless microphones). Visit to location for live broadcast to determine site of broadcast. Pre-record of expert interview 2 (2023-2024 only).	
Session 9.	1-2-1s.	1-2-1s.
Session 10.	Practice run of live broadcast. Feedback, review and address remaining actions.	
Session 11.	Technology checks & final preparations for live broadcast.	Technology checks & final preparations for live broadcast.
Session 12.	Live event.	
Session 13.	Individual review & post-project interview.	Individual review & post-project interview.

Placement students named the live fieldwork broadcast #NclLive during session one in 2022-2023. For consistency this name remained for 2023-2024. During session two the placement provider shared a variety of digital project management tools that could be used to track and manage the development of the project. These included Microsoft Excel, Asana (visual list style), Trello (visual kanban board) and GANTT Project (GANTT chart). Placement students chose to use Trello (Standard version) in 2022-2023 and Asana in 2023-2024.

Eight potential areas of development within the placement were identified and shared with students (Table 4.4). Placement students used these to develop specific individual objectives for their placement.

Table 4.4 Identified skill development opportunities within the live fieldwork broadcast placement.

Skill area
Communication and liaison.
Creative thinking and design.
Developing educational content to meet a project brief.
Public engagement and science communication.
Digital skills.
Problem solving.
Teamwork and collaboration.
Project management.

4.3 Methods

This research is underpinned by a pragmatic epistemological basis, in particular, a Deweyan pragmatism shared in Hammond (2013) whereby both our experiences form our sense of reality and acknowledge the role that a researcher plays in that. This collaboration between myself as both postgraduate researcher and placement provider, and the students themselves works to ensure that outputs from this research are grounded in the experience of the placement.

4.3.1 Logistics of the live fieldwork broadcast

In delivering a live broadcast from an outdoor fieldwork location, five roles were identified. First the main presenter whose role is to deliver the majority of the broadcast live to camera. Second, an additional presenter delivered sections of the broadcast live to camera and moderated digital synchronous communication with viewers. Third, a camera operator based in the field location captured the live broadcast. Fourth, a producer located indoors, remote from the field location received the audio and video feeds and live produced the broadcast, sharing it with the viewers (role five).

A pair of wireless lapel microphones (Rode Wireless II) captured the audio from the two presenters, with the microphone receiver attached to mobile device (iPhone 11). The mobile device was connected in a Zoom meeting using the Zoom mobile app (March 2023). The producer was also connected to that same Zoom meeting, with the live Zoom meeting fed into OBS studio (Version 29.0.1). OBS studio enabled the live producer to add production elements such as transitions, pre-recorded videos and overlay images onto the broadcast. The broadcast was streamed live via YouTube Live. Interaction with viewers was made possible through YouTube comments and via embedded MentiMeter activities during the broadcast (2022-2023 cycle only).

An outdoor wireless network was created using a pocket-sized wireless modem that generated a wireless hotspot. This opened up the possibilities for interesting bioscience locations for the broadcast, with the team able to broadcast from any location without electricity hook-up, providing there was sufficient mobile signal for the wireless modem. The wireless hotspot powered the Zoom meeting on the mobile device and a laptop/tablet device to monitor YouTube comments and MentiMeter outputs (2022-2023 cycle only). Off camera communication between presenters and the camera operator was possible during pre-recorded video segments, with the camera operator using pre-determined hand signals and a whiteboard to communicate with presenters during live segments of the broadcast. WhatsApp was used for the producer to communicate a pre-determined message to signify when the broadcast was live; this meant that the presenters knew when they were live on the broadcast. Table 4.5 lists the in-field and indoor hardware and software required for the live broadcast. Figure 4.1 summarises how the fieldwork environment was networked with lines and modes of communication shared.

Table 4.5 Hardware and software required to network the field environment for a live broadcast.

	Hardware	**Software**
In-field.	Mobile device (iPhone11). Pocket sized wireless modem connected to mobile network. Wireless lapel/handheld microphones with muffles & wireless receiver (Rode Wireless II). Connection cable (Rode 20cm USB C to Lightening Cable). Universal tripod mount holder with cold shoe mount. Tripod. Laptop.	Zoom app (March 2023). MentiMeter. WhatsApp.
Indoors.	Laptop. Monitor screen. Mobile device.	OBS Studio (Version 29.0.1). WhatsApp.

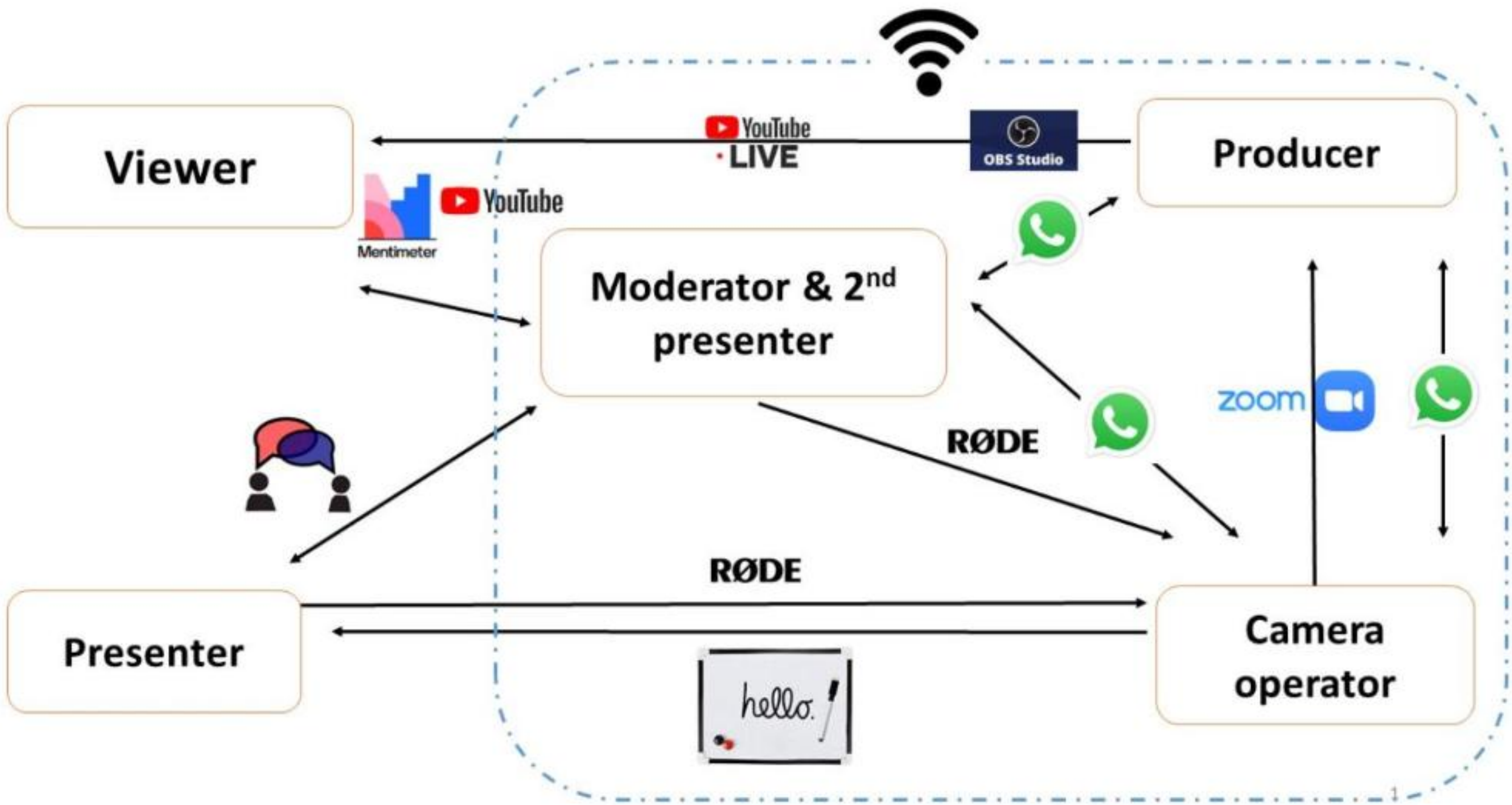

Figure 4.1 Networking the field environment for a live broadcast with lines and modes of communication described.

4.3.2 Semi-structured interviews

Four interviews were conducted with each of the three placement students in 2022-2023 and the two placement students in 2023-2024. Table 4.6 summarises the timing and focus of each of the four interviews. Interview one offered a chance for students to find out more about the placement offer and share some of their initial ideas of live broadcast; it offered opportunities for the students to share how their existing skills and experiences could be utilised within the placement and what they hoped to achieve and develop during the placement. Interviews two and three provided placement students with the opportunity to share their experience of the placement and discuss their progression. With discussions focused to capture feedback to inform ongoing partnership work within the placement, students were also asked to define the level of partnership during the live fieldwork broadcast placement using a ladder of student participation in curriculum design (Bovill and Bulley, 2011). Interview four offered a reflection of the placement, as well as offering space for students to share their thoughts and ideas about the future role of live broadcast in education. During the 2023-2024 cycle, interviews were conducted with each mentor (placement students from 2022-2023 cycle) to capture their experience of this mentorship role in the co-production partnership.

Table 4.6 Timing and foci of the four semi-structured interviews scheduled within the placement.

Interview no.	When	Foci of interview
1.	Pre-placement.	Existing strengths and areas of skill development. Knowledge and understanding of live broadcast.
2.	Week 3.	Management of placement alongside existing commitments. Progression towards objectives. Challenges and areas of concern. Enjoyable aspects and areas looking forward to. Skill development. Defining partnership and reflecting on co-production. Working as a team and suggestions for improvement.
3.	Week 7.	Same as Interview 2.
4.	Post-placement.	Roles during placement, challenges and enjoyable aspects. Progression towards objectives. Skills and strengths. Teamwork and co-production. Future thinking.
***(2023-2024 only).**	Post-placement.	Reflection on the mentor role within the co-production partnership.

The 23 semi-structured interviews followed an interview schedule as a guide (Appendix 4.1) but were flexible in that students could manage the direction of discussion and ask questions back to the interviewee. Ten interviews were held in person and 13 online via Zoom. This was determined by student availability and preference, with each interview audio recorded and subsequently transcribed.

4.3.3 Student self-assessment

Students completed two self-assessments at the start and end of the placement. At the end of the placement students were also asked to explain their response with their responses captured within the semi-structured interviews.

Eight skills areas were identified as development opportunities within the placement. Competency statements were written at a basic, proficient, and advanced level (Table 4.7). Most of these skill areas are transferable outside of the biosciences e.g., ‘Teamwork and collaboration’ and ‘Project Management’. Two skill areas ‘Development of education content’ and ‘Public engagement and science communication’ require the use of students’ biosciences knowledge.

Drawing upon the graduate framework at the placement students’ university (Figure 4.2), students scored their capabilities of these graduate attributes on a scale of 0-10, where 0 was not developed yet and 10 was well developed (Table 4.8).

Figure 4.2 Graduate framework at the placement students' university detailing the twelve attributes of a graduate. Students scored their capabilities of these attributes on a scale of 0-10, where 0 was not developed yet and 10 was well developed.

Table 4.7 Basic, proficient and advanced competency statements of the eight skills areas of the live broadcast placement. Students self-assessed their competency of these skill areas at the start and end of the placement.

Skill area	Basic	Proficient	Advanced
Communication and liaison	Communicates to instruct using both email and social media strategies.	Communicates to instruct, inform, motivate and persuade using a variety of different strategies.	Uses a range of communication strategies effectively for a range of purposes, in diverse situations to achieve end goals.
Creative thinking and design	A logical consistent plan is created to produce the end goal from a list of available options.	Combines existing ideas in original ways working imaginatively to develop a plan to produce the end goal.	Extends existing ideas actively seeking out new approaches to develop a plan to produce the end goal.
Developing education content to meet a project brief.	Educational materials are designed and produced that meet the brief.	Educational materials are designed and produced of a high quality that meet the brief.	Educational materials are designed and produced of a high quality that meet the brief and support learners to make progress against the desired outcomes of the live broadcast.
Public engagement and science communication	Scientific concepts can be communicated appropriately.	Scientific concepts communicated clearly in an engaging manner.	Articulate, interesting, engaging and natural delivery with appropriate pace.
Digital skills	Record and edit video for inclusion within the live broadcast.	Record and edit video for inclusion within the live broadcast. Live produce and broadcast using Live Broadcast Studio and YouTube Live.	Record and edit video for inclusion within the live broadcast. Live produce and broadcast using Live Broadcast Studio and YouTube Live to deliver an interactive event.
Problem solving	Issues are identified.	Issues are identified and addressed appropriately throughout project.	Ability to adapt to changing conditions with ability to think and act proactively and strategically.
Teamwork and collaboration	Roles and responsibilities can be defined. Group outcomes defined.	Use of team-member strengths to address group outcomes. Communicates openly, actively listening to the team.	Actively builds a supportive, trusting environment which supports open communication and active listening. Promotes a sense of shared values with a willingness to help others.
Project management	Tasks and activities can be identified.	Tasks and activities can be outlined with realistic deadline	Project roles and responsibilities can be clearly defined, distributed and monitored.

Table 4.8 Graduate framework identifying the twelve graduate attributes that students self-assessed their level at the start and end of the placement. 0 = Not developed yet and 10 = well developed.

Graduate framework	0	1	2	3	4	5	6	7	8	9	10
Collaborative											
Confident											
Critical thinker											
Curious											
Creative, innovative & enterprising											
Digitally capable											
Engaged											
Reflective & self-aware											
Future-focused											
Resilient											
Globally & culturally aware											
Socially responsible											

4.3.4 Reflective researcher diary

In acknowledgement of the range of emotions that are experienced during SaP projects (Healey and France, 2022), the placement provider kept a reflective researcher diary throughout the placement, with individual entries completed within 24 hours of each placement session. A template was used to guide the reflective entries (Appendix 4.2) with headings to record a description of the session (Wright and Hodge, 2012), feelings identified during the session (Healey and France, 2022), opportunity to evaluate the success of the session, identify key conclusions from the reflection (Trehan and Rigg, 2012) and determine any actions to be implemented (Harrison *et al*., 2003).

4.3.5 Placement student reflective log

Placement students produced a reflective log, which was submitted as a piece of summative assessment for the module. The placement provider did not see these final reflective logs, nor was involved in the marking of these. These reflective logs were not analysed as part of the data within this project. However, the students used these during the 1-2-1s and post-project interviews, drawing upon their reflections to inform discussions with the placement provider.

4.3.6 Data analysis

Each interview was transcribed and analysed using the six-stage analytical guidance applied to reflexive thematic analysis (Braun and Clarke, 2019; 2020) whereby the researcher is actively involved in producing themes from the data. A predominantly inductive approach is adopted with theories developed from the data rather than being imposed beforehand. This means that the themes presented within this research represent what participants have communicated within the research, but I acknowledge the role that the author as the researcher and placement provider plays in constructing those themes during the data analysis process. Additionally, two frameworks were applied to the data to support deductive analysis related to specific research aims. Firstly, values which support the development of a partnership (Healey *et al*., 2014) have been used to identify aspects of the live broadcast placement that promoted a sense of partnership. Secondly, a skills framework (Peasland *et al*., 2019) was used to define skills identified and developed within the placement.

All students self-assessed skill competencies were totalled across the basic, proficient, and advanced categories for the pre and post self-assessment. Total self-assessment levels for each the graduate attributes were compared pre and post to determine cumulative change in the graduate attribute for all students combined.

4.4. Findings

4.4.1 Feasibility of a low-cost and low-tech solution to live broadcasting

Placement students successfully co-designed, co-developed and co-delivered a live fieldwork broadcast in both 2022-2023 and 2023-2024. Table 4.9 summarises each of the broadcasts. Key features of each of the live broadcasts included engagement with bioscience experts at a variety of career stages, sharing of local and topic marine or coastal research and the opportunity for live interaction with the audience (Table 4.9). As a live fieldwork broadcast had not been undertaken at Newcastle University before, and the student co-production partnership was a new placement opportunity offered, it was decided by the author that the first live fieldwork broadcast in 2022-2023 would be aimed at an internal audience only. This was a new optional learning opportunity that was offered to the first-year students on an afternoon free from timetabled sessions. For the second-year of the live fieldwork broadcast, it was decided by the author to broaden the available audience by developing an external live broadcast that could be watched by learners ages 16+ with an interest in marine biology. Both live fieldwork broadcasts provided specific learning aims for the audience, which were communicated via the live fieldwork broadcast website which students co-designed (link in Table 4.9).

Table 4.9 Summary of the live fieldwork broadcast key features in 2022-2023 and 2023-2024.

	2022-2023 live broadcast	**2023-2024 live broadcast**
Theme.	Contemporary local marine issues.	Marine biology field research in Northeast of England.
Location.	Blyth, Northumberland.	Seaton Sluice, Northumberland.
Content.	Interview with Dr Gary Caldwell on marine mass die offs. Laboratory and field methods for sampling plastic in the marine environment. Identifying plastics in marine samples. Marine plastic interactive quiz. Q&A. Positive news about coastal futures of North-East.	Undergraduate student interview on fieldwork at Newcastle University. Interview with Sarah Dickson, Postgraduate Researcher on cetacean research. Sounds of the Sea live activity. Interview with Professor Clare Fitzsimmons on career and current research. How drones are used to research the coastal environment. Q&A.
No. of viewers.	102.	45.
Intended audience.	First-year Marine and Bioscience undergraduate students at Newcastle University.	Students aged 16 year plus who have an interest in Marine Biology.

Webpage.	https://bit.ly/NclLive2023	https://bit.ly/NclLive2024

4.4.2 Emotions and attitudes

A summary concept map of the themes identified within the reflexive thematic analysis of the interview data presents four challenges and four main areas of enjoyment shared by placement students when reflecting on the live fieldwork broadcast placement (Figure 4.3). Table 4.10 provides some student quotes to illustrate the themes within the concept map.

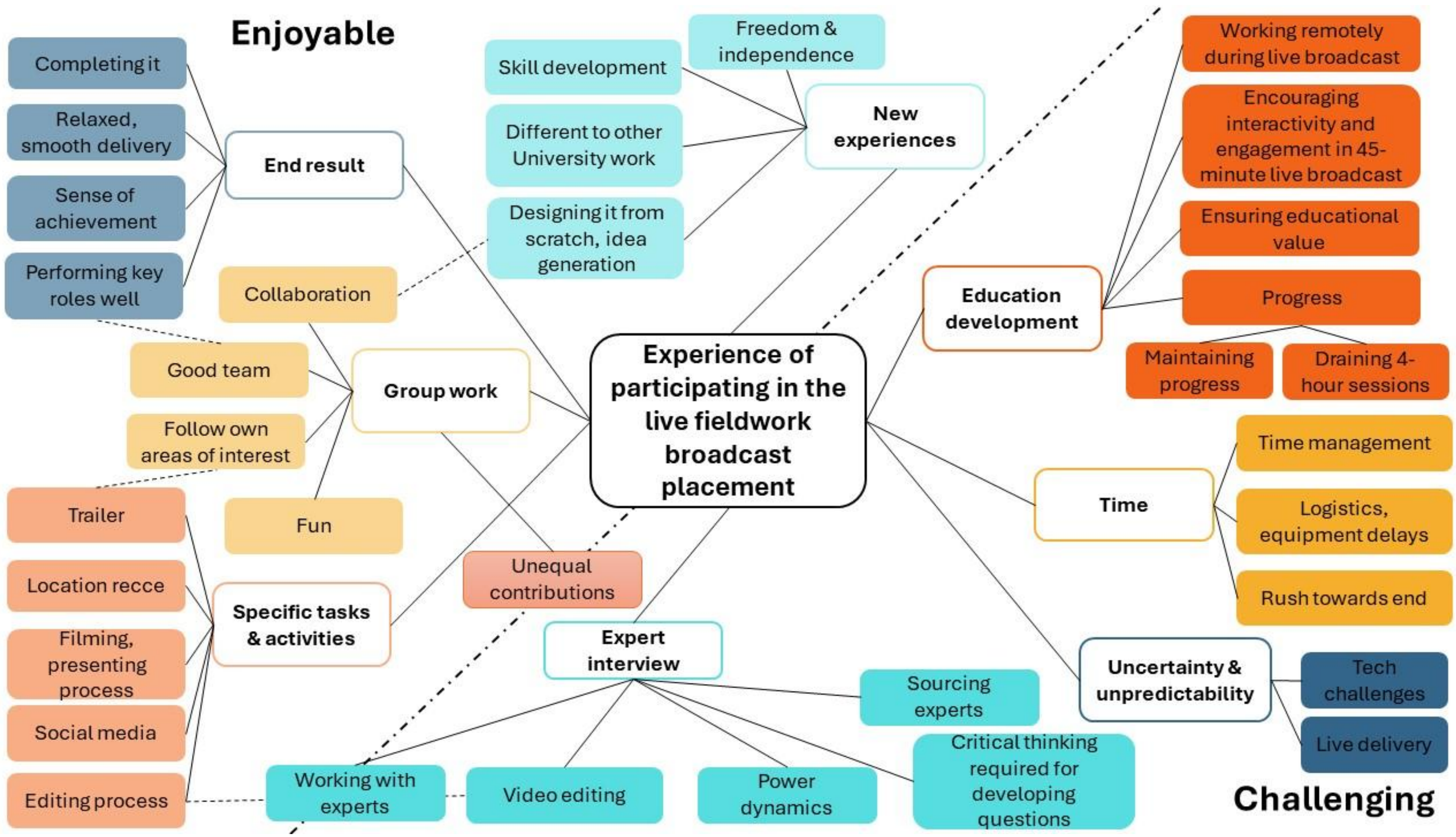

Figure 4.3 Concept map summarising the results of the reflexive thematic analysis on placement students' experience of participating in the live fieldwork broadcast placement. Dashed lines between themes indicate links between themes.

One of the areas of challenge was the development of the pre-recorded expert interview segment of the live fieldwork broadcast. Preparing suitable interview questions which enabled the academics to share their bioscience research in an accessible manner required critical thinking and the use of decision-making skills to make editorial decisions when editing the footage into the interview segment. Interestingly a specific area of challenge related to the expert interview was working with and interviewing one of the placement student's lecturers (Table 4.10). This highlighted an issue around student identified power dynamics of a student interviewing one of their lecturers.

Time was a theme that was identified as a challenge for the placement students during analysis. There were some aspects of the placement that were out of control of the team and impacted upon the timing of the project. Equipment delays resulted in logistical challenges. Although it was challenging, students demonstrated problem-solving skills to address the logistical delays (Table 4.10). The looming deadline of a fixed live broadcast caused some anxiety to placement students, especially with students' other commitments (Table 4.10).

The development of educational content was something that was new to all of the placement students. Unsurprisingly, this was an area of challenge. Specific challenging aspects of this were related to ensuring educational value in what they were delivering and maintaining interactivity with viewers during the broadcast (Table 4.10). During the placement, the placement students had a training session with the FSC who have delivered multiple live broadcasts. The placement students used this training opportunity to seek advice and confirmation about some of their education development ideas. Yet despite this, the nature of the partnership, with students co-creating the content and the delivery mode of broadcast, aspects of the placement still remained unpredictable, which led to feelings of uncertainty with the placement students tackling unprecedented challenges (Table 4.10).

One of the enjoyable aspects of the placement was the end-result of the live broadcast, with placement students reflecting on the sense of achievement felt after delivering it (Table 4.10). Individual students had their own areas of responsibility during the placement, with these personal projects being aspects that were particularly enjoyable (Table 4.10). The placement provided new experiences for the students, and these were found to be enjoyable, different from their existing experiences at university and offered opportunities to do new things with new people (Table 4.10).

The students enjoyed the group work associated with the placement, with the experience of working within the team on the live broadcast placement changing their outlook towards group work and offering the chance to liaise and work with expert researchers in the biosciences (Table 4.10), although one student had some concerns about their role within the team environment (Table 4.10).

Table 4.10 Student quotes to illustrate identified themes within the concept map, reflecting on placement students' experiences of participating in the live fieldwork broadcast placement.

Theme	Sub-theme	Student quote
Expert interview.	Power dynamics.	*"He is my lecturer... He does decide my grades…don't want to annoy him in any way…that was one of the big challenges for me." S151*
Time.	Logistics, equipment delays.	*"If the equipment isn't there for like the actual demo (of the) method itself, I could very easily just describe that. I think the most important bit is actually making sure we've got some plastic, in a dish, in a microscope." S150*
	Rush towards end.	*"I would say that towards the end. I thought we were sort of in a rush to get things done, which was a bit stressful." S150*
	Time management.	*"So, I would say it's getting a bit more hectic with the placement we've got a lot more stuff to do. Unfortunately, that is matching with I'm now having a lot more assignments due. I have three assignments on the same day, the day right before we film the broadcast. So, it's a bit stressful having to plan all of that, but I am managing." S153*

Education development.	Encouraging interactivity and engagement.	*"I think one of the first issues we came across were how are we going to be engaging, maintain engagement." S154*
		"So, making educational content and then making sure in the creative process, it's in a digestible manner, and that you keep the attention." S150
Uncertainty and unpredictability.	Live delivery.	*"Unpredictable… as in anything could happen. It could get to the day, we can only plan so much. So, it really does just depend on the day." S151*
	Tech challenges.	*"…big one was the Monday before the broadcast and the video wasn't working, and we had to like troubleshoot and try and find a different solution, and we were trying a lot of different methods to try and fix it." S154*
End result.	Completing it.	*"I had a great time actually delivering the final broadcast…watching what we created, and then being able to actually do a good job." S150*
	Sense of achievement.	*"I think it was just interesting the sort of ideas that we wanted to pursue about research in the northeast, I think, that was quite interesting….I think it was nice to sort of see that you can do things that feel a bigger part, like feel like bigger thing, but also I think I just enjoy the entire process and just seeing what is actually involved with...creating a project like this." S154*
Specific tasks and activities.	Trailer.	*"I really liked when we talked about a trailer and I thought oh my goodness that's like right up my street." S151*
New experiences.	Skill development.	*"And it was, it was fun learning, like different skills and working collaboratively with different people." S153*

	Different to other. University work.	*"Not the same as going to lectures and doing essays. So, from my perspective I think it's really quite refreshing." S152*
Group work.	Collaboration.	*"I really really loved collaborating with everybody, with our core team and our experts, and then with our sort of mentors from last year. That was really useful...And then just getting to work with everybody on all of that was just really nice." S153*
	Good team.	*"I think this is one of the best, if not the best team environment that I've been in." S151*
	Good team. Fun.	*"It's definitely changed my opinion of group work, because normally…I don't really enjoy doing group work. It was actually nice to work in a group where everyone like wanted to be there and everyone enjoyed what they were doing." S152*
	Unequal contributions.	*"…worried that I would be seen as not contributing that much as XX is very vocal with their ideas, whereas I am less confident, and their ideas have all been good." S154*

4.4.3 Defining the co-production partnership for the live fieldwork broadcast placement

Using values that are defined as integral to a SaP approach (Healey *et al.*, 2016), aspects of the live broadcast placement that promoted a sense of partnership can be identified from the deductive content analysis of the students semi-structured interview and researcher reflective diary entries (Figure 4.4). All eight aspects can be evidenced from student interview data (Figure 4.11) and researcher reflections, showcasing that the placement promoted these eight partnership values (identified in orange in Figure 4.11). However, there were several aspects of the placement identified from within the data that did not promote specific partnership values (identified in blue in Figure 4.11).

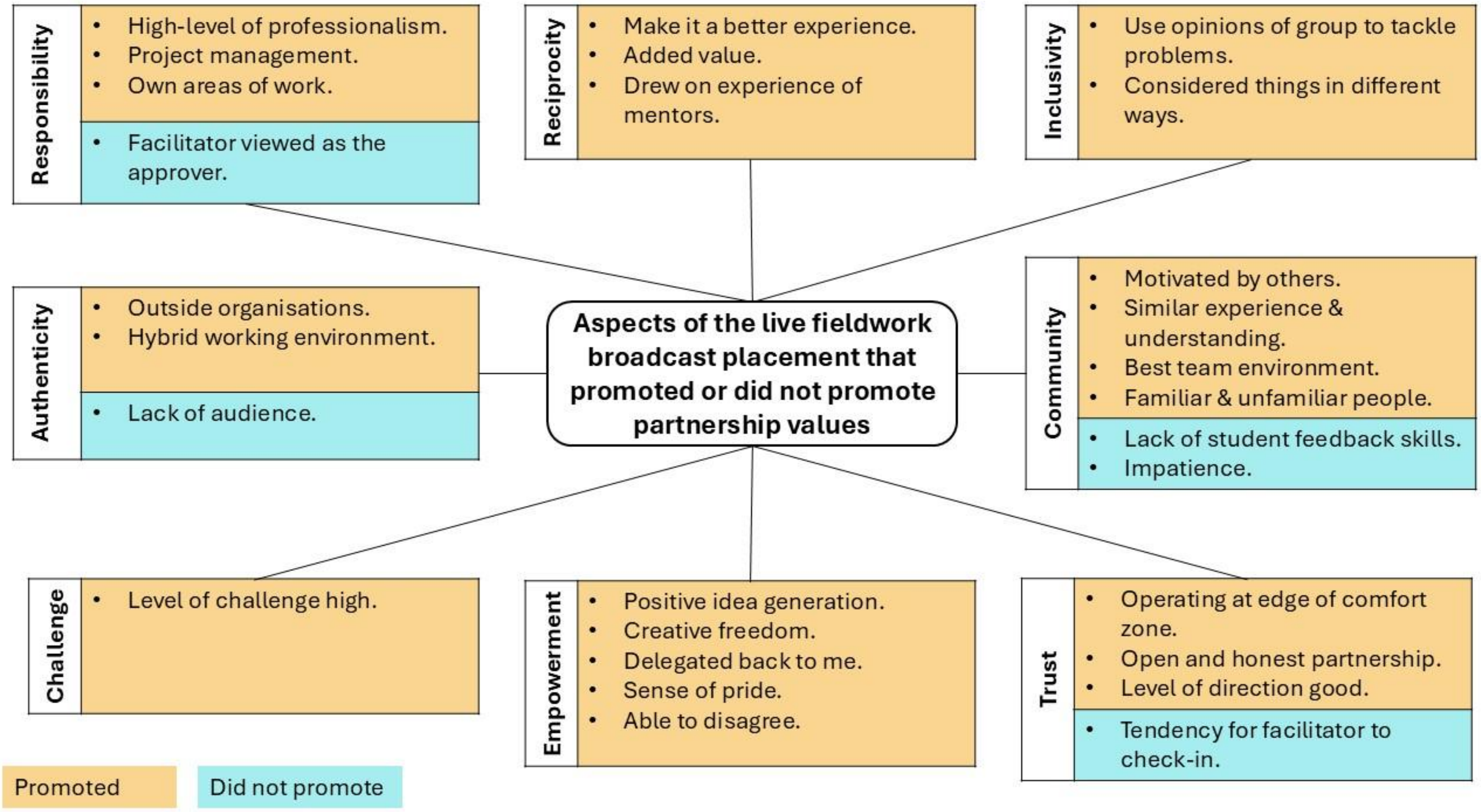

Figure 4.4 Aspects of the live fieldwork broadcast placement identified from the deductive analysis of the student semi-structured interviews and researcher reflective diary entries that promoted or did not promote the eight partnership values as identified as integral to a 'Students as Partners' (SaP) approach (Healey et al., 2016).

Empowerment was a partnership value that was strongly evidenced in the data, the idea generation task to determine the theme (Week 1) and storyboarding (Week 2) provided placement students with the ability to the determine the direction of the live broadcast and make decisions on content within it (Table 4.11). This empowerment was also identified in the researcher reflections where it was identified that placement students delegated tasks back to the placement provider to be completed in the gap between sessions, as well as identifying times when the group were able to disagree and offer alternative suggestions.

Community was an aspect of the live broadcast placement that students drew upon extensively within their interviews, and the positive team environment was identified as a particular area of enjoyment from the project. Students reflected that working with other students who had similar levels of experience and understanding was a positive in the partnership and offered opportunities to identify strengths in others and act as a motivator (Table 4.11).

There were times within the researcher reflections where it can be identified that the provider of the placement, operated at the edge of their comfort zone; for example, with the use of OBS to live produce. The placement student and placement provider learned together, using outside sources of support, with the student ultimately becoming the expert in that area and teaching aspects of their role back to the placement provider (Table 4.11).

During the placement, students each worked on their own areas of responsibility, and effectively managed that aspect of the project (supported by Trello and Asana online project management tools). The team showcased a sense of responsibility in the partnership, with students commenting that these project management skills would be useful elsewhere (Table 4.11) and supported them to tackle one of their specific areas of development for the placement (planning and organisation) (Table 4.11).

From conception of the project, the co-production of a live fieldwork broadcast in 35-hours with novice placement student was identified as a challenge. Ensuring the correct level of challenge within the placement was something that remained present throughout the project (Table 4.11). It required a strong partnership with good communication and regular check-ins, which asked students to evaluate the current level of direction and suggest changes to meet their needs (Table 4.11).

Table 4.11 Student reflections on aspects of the live fieldwork broadcast placement that promoted or did not promote the eight partnership values as identified as integral to a 'Students as Partners' (SaP) approach (Healey et al., 2016).

Partnership value	Student quote to illustrate the partnership value
Empowerment.	*"I was shocked that we were able to come up with that many ideas, like all of us, like everyone was included in it…I think it was good because we were all confident enough to share what we were thinking." S152*
Community.	*"I think we worked, you know, brilliantly together. I think you know the freedom that we had…I think it was (a) perfect level." S150*
	"It's quite nice to see a different part of someone who is on the same course as you." S151
	"They're very productive, so that will then make me more productive." S150
Trust.	*"Direction is actually quite good, because you let us do our own thing. You let us go ahead…but I know I can come to you if I have any questions…" S154*
	"I think that further down the line, we may want less guidance, but at the moment we are still learning and trying to understand the process, and therefore we should maintain the current level of dependency. However, once we have the hang of it, we may feel comfortable enough to undertake certain tasks by ourselves." S153
Responsibility.	*"…just sort of seeing how (Trello) would work for future projects." S151*
	"…having the sort of independent role on the day…I have to make sure that everything is planned out and organised as much as possible, because no one else can take over for me. So, it is sort of like knowing that it is all on me. Sort of made me make sure that …everything that was possible (is) in place." S152

Challenge.	*"It was difficult at the start…it was quite daunting the thought of it." S151*

Although not identified within the student interviews there were three themes that can be identified from the researcher reflections that did not promote specific partnership values. Firstly, there were times when the placement provider was approached by the placement students as the 'approver'. This improved over time but did not promote the value of trust within the earlier stages of the project. Secondly although the broadcast was streamed live via YouTube to its audience, the uptake for viewing #NclLive in both 2022-2023 and 2023-2024 was low (2022-2023- 102 views; 2023-2024- 45 views). This was disappointing and prevented the partnership from maintaining authenticity as a key partnership value. Finally, there were several times when the placement provider felt the need to check-in with the progress of development on several aspects, although these were not all acted on. Upon reflection this stemmed from comparisons of pace and style of working between the placement provider and that of the placement students. This was able to be addressed as the partnership developed and the communication tools and styles adapted to suit the needs of the group.

During interviews two and three, placement students were asked to define the level of partnership using a ladder of student participation in curriculum design (Bovill and Bulley, 2011). Students found it challenging to define it absolutely using the categories given, often commenting that their understanding of the partnership was across two descriptors. Table 4.12 summarises how students described the project at two stages of the placement.

Table 4.12 Defining the partnership of the live fieldwork broadcast placement using a ladder of student participation in the curriculum design (Bovill and Bulley, 2011). Grey shading refers to students defining the partnership in those terms, white shading denotes that students did not define the partnership in those terms.

Ladder of student participation		Description of participation	Interview 2 (Week 3)	Interview 3 (Week 7)
Increased level of participation.	**Students control decision making and have substantial influence.**	Students in control.		
		Partnership- a negotiated curriculum.		
	Students have some choice and influence.	Students control some areas of choice.		
		Students control prescribed areas.		
	Tutors control decision making informed by student feedback.	Wide choice from prescribed areas.		
		Limited choice from prescribed areas.		
	Tutors control decision making.	Participation claimed, tutor in control.		
		Dictated curriculum, no interaction.		

The students did not perceive that it was the 'placement provider' in charge of their decision-making as their responses aligned to the student control element of the ladder (Table 4.12).

During interview two (Week 3) there was a broader of partnership definition from students having control of prescribed areas to students in control. By interview three (Week 7) of the placement the partnership definition became more tightly defined between 'partnership- a negotiated curriculum' and 'students in control'. In week three, one student commented on the freedom within the partnership (Table 4.13). In Week 7, one student described how the partnership was working (Table 4.13). One student reflected on the collaboration between placement students and the placement provider within the partnership at the end of the placement (Table 4.13).

Table 4.13 Student quotes from placement interviews reflecting on the live fieldwork broadcast partnership.

Week	Student quote
3.	*"…obviously we have a massive say in what happens and what direction it goes in, but obviously you do as well. And you with the PowerPoints and everything you know what you want to happen in the session, and we try and get it done. But I think… we've been given us a lot of freedom as well." S151*
7.	*"So, I quite like how it's sort of been, it's just sort of like we have to sort of, we work things out for ourselves." S152*
Post-placement.	*"I would say a partnership as you have pushed us to think about things and come up with our own ideas and solutions, instead of just telling us. However, you have stepped in when we have struggled to think further. You have given us a framework to work in, but it is our choice what we do within that framework. I would say that within the given framework we have worked collaboratively to negotiate the development of the aspects within that." S154*

4.4.4 Impact of participating in the live fieldwork broadcast

Student self-assessment of skill competency of the identified placement skill areas pre and post placement give an indication of the impact of participating in the live fieldwork broadcasts. Figure 4.5. summarises the change (pre and post) in the number of competency statements categorised as basic, proficient, and advanced totalled across all placement students' competencies (Figure 4.5).

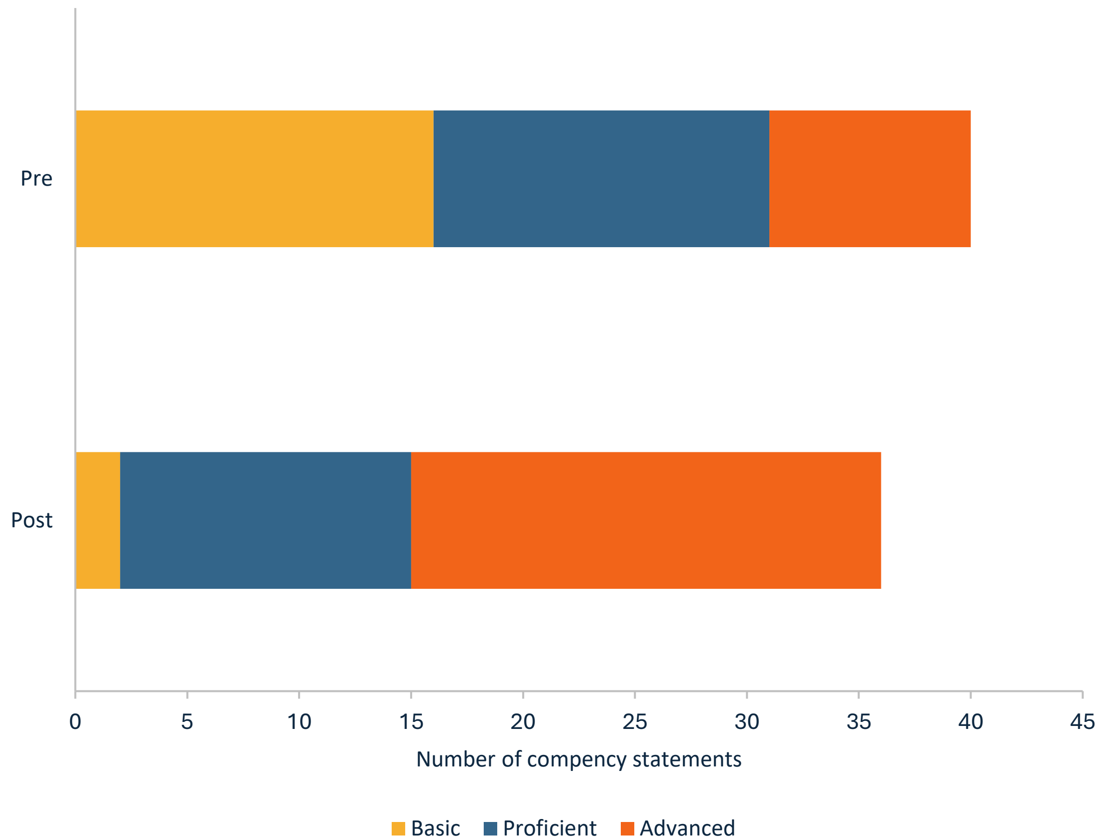

Figure 4.5 Number of competency statements and their level of competency (basic, proficient, advanced) identified pre and post placement by the placement students.

Post-placement, there were fewer overall assessments of competency as students commented that some skill areas were not relevant to the objectives that they set for their placement and as such did not rate their competency post-placement in this area. Across all students the number of proficient competency statements remained stable pre and post (Figure 4.5). There was a decrease in basic competency levels and an increase in advanced competency levels (Figure 4.5). This shows that the placement had an impact on student reported competencies of skill areas. Post-placement at least one student reported advanced competency level for each skill area (Figure 4.5), highlighting the value in student derived individual objectives, areas of development and specific roles and responsibilities during the placement.

Student quotes from the interviews that took place during placement indicate progress against students' own objectives, and the identified development areas of the project (Table 4.14).

Table 4.14 Student quotes from placement interviews that indicate progress towards the development areas.

Development area	**Quote indicating progress**
Communication and liaison.	*"Another objective I had was speaking to experts. So being able to create sort of a network, and then how to reach out to this network. It did definitely help that you had emailed our experts beforehand saying I was going to contact them… So, I'll have to bear that in mind, in the future, when I contact people to collaborate with them." S153*
Creative thinking and design.	*"Initially, I wanted to have like sort of something completely like if it was just my own something like completely novel. But as I sort of went on, I reflected, that that's not, you know. That's not entirely feasible, like in practice. So, I think when I reflected on that, it was then just sort of adding my own elements to that part, instead of creating something that (was) entirely new." S150*
Developing education content to meet a project brief.	*"In terms of education content. I would say that we are advanced in that because we did think very, you know, thoroughly on what would be the best sort of content to educate people, but also keep them interested. Which was our brief. So I thought what we designed was quite high quality, and we did support the learners during the broadcast." S154*
Public engagement and science communication.	*"…my first objective was sort of increasing, presenting confidence, especially in front of a camera. So, what I did for that was a lot of practice. You know, with practicing the script points, but also like doing our microteaches that help(ed) the sort of presenting stuff. So I'd say that the progression of that was quite fluid, like we sort of built upon things that I knew how to do already in the beginning, and then added onto that progressively. So, I felt more confident when doing the live presenting, which I think is really useful." S153*

Digital skills.	*"I wanted to edit the footage in sort of like an educational way, in a professional way. And then gain confidence in using the live production software, and obviously meeting those goals, I did a long practice with OBS before the actual broadcast. And videos I'd say we're good. They were clean, and they had all the information they needed to have in them." S154*
Problem solving.	*"…once we identified the problem, we sort of knew what the issue was, but we didn't know how to fix it. So obviously the trial and error of how to fix that." S154*
Teamwork and collaboration.	*"I think I surprised myself with like directive on that one, because like it's weird because we're in this dynamic where we're all seen as equals to each other. It was kind of like I had to step forward, and kind of take charge." S151*
Project management.	*"… having the sort of independent role on the day…I have to make sure that everything is planned out and organised as much as possible, because no one else can (do) it for me. So, it was sort of like knowing that it was all on me. Sort of made me make sure that, everything that was possible (was) in place…making the list of everything we need to do, and then, sort of sorting it out into urgency order before we put it on Trello…so like that helped as well with like prioritising and organising things." S152*
Team management.	*"I think I may be more capable of sort of leading teams, maybe in the future. Because I've already got a bit of practice at sort of making decisions, and how they would affect other people and things like that." S153*

The placement provided students with the opportunity to develop knowledge-based skills, transferable skills and personal attributes. Table 4.15 presents the results of the deductive content analysis of the placement students semi-structured interviews and the researcher reflective diary entries. Table 4.15 summarises the skills that students and placement supervisor identified were developed during the placement process. In total 34 skills were identified, with 88% of skills identified by at least one placement student. Half of all the skills identified can be defined as transferable.

Table 4.15 Skills identified from the deductive content analysis of the semi-structured interviews and the reflective researcher diary entries as being developed during the live fieldwork broadcast placement.

	Knowledge	**Transferable**	**Attributes**	**No. of skills**
Identified by all of the placement students.		Team and group work. Creativity, idea generation.		2
Identified by four of the placement students.		Project planning, management. Collaboration. Communication.	Confidence.	4
Identified by three of the placement students.	Science communication, scientific knowledge. Digital skills.		Reflective, self-aware Independence	4
Identified by two of the placement students.	Social media. Research skills. Education development. Interview. Live producing.	Critical thinking. Leadership. Decision-making. Presentation. Problem solving. Personal responsibility, organisation.	Resilience. Working well under pressure. Adaptability, flexibility.	14

Identified by one of the placement students.		Networking. Time management. People management. Delegating.	Recognising strengths in others. Thinking outside the box.	6
Recognised by researcher/placement supervisor only.	Marketing.	Coaching, mentoring. Feedback.	Professionalism.	4
No. of skills.	8	17	9	

At the start of the placement students scored their capabilities of some graduate attributes on a scale of 0-10, where 0 was not developed yet and 10 was well developed. At the end of the placement, students revisited these. Figure 4.6 shows the cumulative change of all five placement students' self-assessment of these graduate attributes with Table 4.16 providing some student reflections on these graduate attributes.

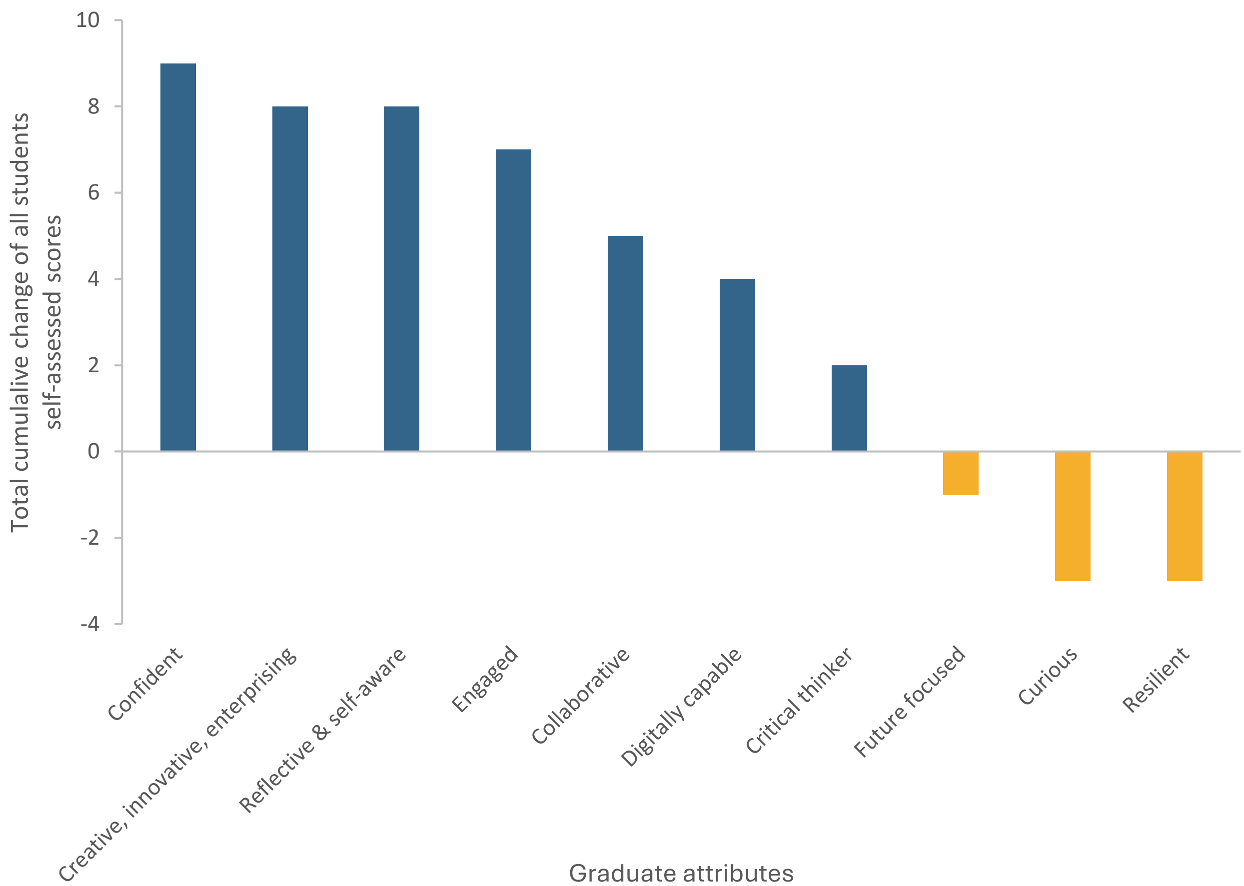

Figure 4.6 Cumulative change in self-assessment scores of graduate attributes. Graduate attributes in blue indicate an increase in the self-assessment scores and those in yellow indicate a decrease in the self-assessment scores.

'Confident' was the graduate attribute that had the largest increase in cumulative self-assessed scores (Figure 4.6; Table 4.16). 'Creative, innovative, enterprising' and 'Reflective and self-aware' were two graduate attribute areas that also had a large increase in cumulative self-assessed scores (Figure 4.6; Table 4.16).

Interestingly despite the live fieldwork broadcast placement adopting digital technologies throughout, placement students did not identify much increase in their self-assessed score for 'digitally capable'. This is perhaps a reflection on the distinct roles that students performed during the live broadcast. Additionally, despite two students identifying resilience as a skill they had developed during the broadcast, there was a decrease in the self-assessed scores of the 'Resilient' graduate attribute. This is perhaps linked to both the overall level of challenge of the live fieldwork broadcast placement, and logistical challenges identified.

Table 4.16 Student reflections from placement interviews on their progress towards graduate attributes.

Graduate attribute	Student quote reflecting on their progress towards that attribute
Confident.	*"I just feel like trying these new skills. And as part of working as a team, I feel like I've definitely become more confident and felt I can make sure I have my own ideas there." S154*
	"I'd say that my confidence is quite high level. Because of all of the presenting, all of the interviewing, the live stuff." S153
Creative, innovative, enterprising.	*"I feel like we used some really cool concepts…inside the broadcast." S154*
Reflective and self-aware.	*"I feel like I've learned to sort of check in more and think about, like, oh, maybe this isn't going so well. But we've also got this, and this was good…I've been able to like sort of be honest with reflection and also look at good things, even if it isn't going to plan." S153*

4.4.5 Role of mentoring

The co-production partnership benefitted from multiple levels of mentoring. Organisations/institutions (Open University and Field Studies Council) with experience and expertise in live broadcasting offered their support and training to the core team. Internal colleagues were involved through their contributions to the content of the live broadcast and as supervisory support to the placement provider.

The 2022-2023 students who had successfully completed their placement and navigated the co-production process were identified as an asset that would benefit the live fieldwork broadcast. They were employed in a peer mentor role to support the 2023-2024 placement students. The structure of support for the 2023-2024 live fieldwork broadcast is summarised in Figure 4.7. The experience of the mentors was positive, and they were able to again demonstrate some of the skills that they had developed during their placement, the following year in the mentor role (Table 4.17). This had a positive impact on the experience of the 2023-2024 placement students (Table 4.17).

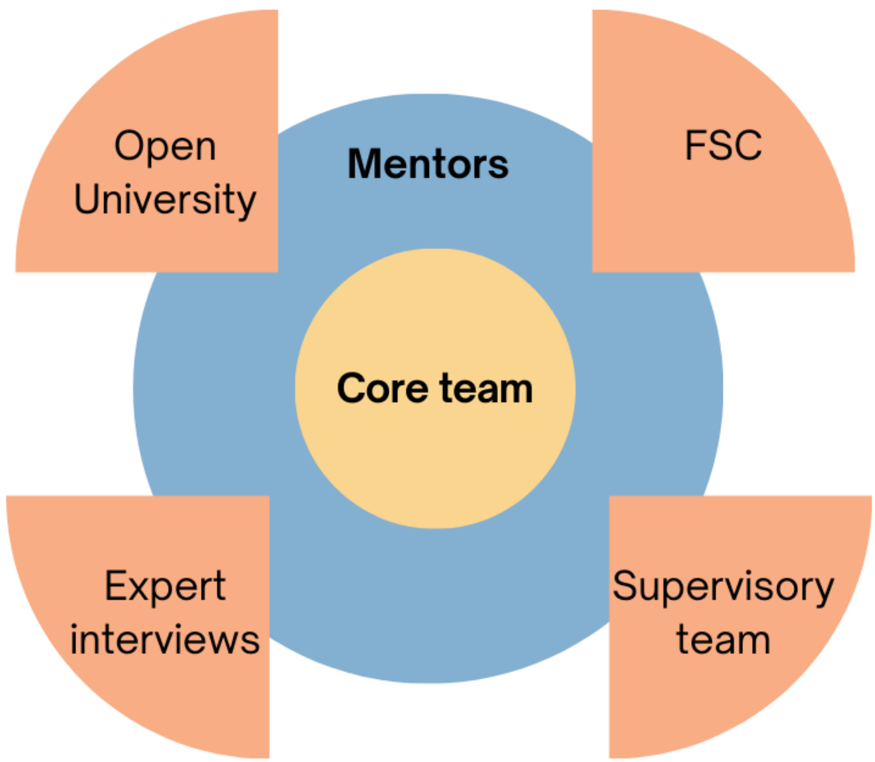

Figure 4.7 Structure of support and mentorship for the 2023-2024 live fieldwork broadcast placement.

Table 4.17 Student quotes from placement interviews reflecting on the mentoring support within the live fieldwork broadcast partnership.

Student quote
"What helped would definitely be the first session, obviously, where we all came in and sat down. And then, like, I don't know, had a bit of a chat, and it was just like Q&A sort of thing. I think that helps because it kind of exposed us to like the situation. So, it gave us time to figure out like what we needed to do and how we should do it. And sort of I don't know, address the needs of like the mentees." S152
"I know they were very helpful, especially when they were providing their own sort of advice and talking about their own experiences. And it was nice to be able to speak to them people who have already done it before...they were really helpful, and obviously help(ed) deliver the actual broadcast in the end." S154

4.4.6 Future role of live broadcast in fieldwork education

As live broadcast is a novel delivery mechanism, the learnings from the 2022-2023 co-production partnership informed the development of the 2023-2024 co-production partnership for the live broadcast (Table 4.18). The perceived power-dynamics with expert interviewee in 2022-2023 were addressed by more thorough onboarding of those academic staff being interviewed in 2023-2024 with meetings scheduled between placement students and academic staff prior to the interviews taking place. Although the level of challenge was likely to remain the same between 2022-2023 and 2023-2024, having the 2022-2023 placement students as mentors to share their experiences and top tips for success would hopefully minimise associated issues with the level of challenge, by supporting the 2023-2024 placement students that the end-goal of the live fieldwork broadcast was achievable. To avoid the placement provider needing to 'check-in' with placement students to keep abreast of progress, modelling of effective use of the project management tools to encourage use was undertaken.

Table 4.18 Iterative development actions based on challenges of 2022-2023 to inform 2023-2024 live broadcast.

Challenges identified in 2023 live broadcast	Actions to minimise challenge in 2023-2024
Level of challenge.	Invite 2023 placement students to attend first part of session 1 or to record a video to share their experience and their top tips based on their experience in 2022-2023.
Power dynamics with expert interview.	Spend time onboarding the person who is participating in the expert interview so they understand the SaP approach. Arrange a pre-interview meeting between student interviewee and the expert.
Logistics affecting equipment delays.	Placement provider to continue to manage the acquiring of equipment and do so as early as possible.
Low uptake of audience viewers.	Liaise with organiser of fieldwork to encourage participation of learners. Develop a marketing plan within the placement to support sharing of the broadcast with internal and external audiences. Broaden audience by developing a live broadcast which can be watched by learners ages 16+ with an interest in marine biology. Specific focus during education development on audience engagement during live broadcast.
Placement provider seen as the 'approver'.	During interview stage be explicit sharing that placement students will work with the placement provider in a co-production partnership to co-design, co-develop and co-deliver the live fieldwork broadcast.
Placement provider 'checking in with progress'.	Encourage the use of the project management tool to track progress via modelling.

Post placement, students were asked to reflect on future possibilities of live broadcast within biosciences fieldwork and the impact that these might have on learning within HE. One student recognised the value of live broadcast to promote inclusive and accessible bioscience fieldwork opportunities (Table 4.19). Other students saw value in live broadcast enhancing existing learning within their bioscience degree including as an authentic assessment opportunity (Table 4.19).

Table 4.19 Student quotes from placement interviews reflecting on the future of live fieldwork broadcasts.

Student quote
"If people aren't comfortable coming into university or if they're in a different country, or they've broken a leg, or just had surgery. They like can't come into the lectures, I think having a live broadcast that you can log into which will make you feel more involved, and you're actually almost like with them and seeing it. Good to increase interconnectedness. Make it more accessible, more engaging." S151
"I think lab work. Because you sort of have lab videos. But they're edited like if it was a dissection or something. I feel like having that live so you could see like exactly how it's the whole process." S150
"It could be used as an assessment in a way…I feel like assigning a group and saying, oh, you've got to create this short, even if it was just like a 5-10 minute sort of fieldwork task. I feel like a lot of skills are involved in delivering. It's not just doing the field task and how well they did it…it involves everything else behind the scenes as well." S154
"…next year the first years wanted to do a fieldwork. They could speak to one of us, you know, second or third years live in (the) field on how to carry out this fieldwork, and it would be the student carrying out this demonstration. And then, maybe during lectures it could be a student speaking live about what they know about whatever the lectures discussing." S153

Figure 4.8 Future possibilities of live broadcast in fieldwork.

Reflecting on student suggestions and researcher reflections Figure 4.8 summarises some of the future possibilities of live broadcast in bioscience fieldwork and suggests the potential impact of these possibilities. These suggestions include the potential to form partnerships with international organisations and research institutions, allowing local experts to deliver live fieldwork broadcasts directly to HE learners, regardless of location and without the need for travel. Additionally, early-career researchers, such as postgraduate and post-doctoral researchers could broadcast from the field during data collection phases of their research, connecting undergraduate learners with the research occurring in their institutions. Finally, equality of access of fieldwork could be improved by offering peer-to-peer broadcasts during overseas fieldwork, helping to minimise barriers to participation.

4.5 Discussion

The purpose of this chapter was to identify the feasibility of co-producing a low-cost and low-tech live fieldwork broadcast with undergraduate students via a student placement. The impact of participating in the live broadcast placement was identified with students offering their definitions of the co-production partnership. The future of live fieldwork broadcasting is also discussed.

The low-cost, low-tech solution was effective in networking the fieldwork environment to produce a live fieldwork broadcast. While resource implication (Fletcher *et al.*, 2007; Welsh *et al.*, 2013) and anxiety over the technologies (Welsh *et al.*, 2013) have been identified as barriers to adoption of digital technologies in fieldwork, the use of simple, easy to use technologies have been identified as a way of overcoming these barriers (Maskall *et al.*, 2007). This current research provides evidence to support the view of simple and easy to use technologies supporting integration. Working in partnership, undergraduate students acquired the knowledge and skills to use this simple and easy to use technology to produce a live fieldwork broadcast during the 35-hour placement. The schematic shared in this research which documents the flows of information and layers of communication used in a networked environment (Figure 4.1) is something that has not been presented in other research on live broadcasts in either indoor (Williams *et al.*, 2011; Iwaki *et al.*, 2013; Fang *et al.*, 2022) or outdoor education settings (Cassady *et al.*, 2008; Robert and Lenz, 2009; Fang *et al.*, 2022). Such a model can easily be replicated for other live fieldwork broadcasts both within biosciences and other disciplines such as geoscience, geography, environmental sciences or earth science with minimal additional costs and/or equipment.

Although live broadcast as a method of educational delivery is well-documented within HE surgical education (Williams *et al.*, 2011; Iwaki *et al.*, 2013; Fang *et al.*, 2022), its use within a geography, earth and environmental science (GEES) or bioscience HE fieldwork setting is limited to institutions with remote learner populations (Open University, 2023) and specific programs such as GEOspace, which have focused on access and inclusion with geoscience fieldwork (Marshall *et al.*, 2022), both with heavy resource requirements (staff and technology). Broadening to all educational settings, much of the live broadcast educational delivery involves a delivery model of expert to novice (Cassady *et al.*, 2008; Stagg *et al.*, 2022), and although participation through decision-making during the broadcast can be in-built, there are limited examples of learners driving the content of these live fieldwork broadcasts. Utilising the well-documented benefits of a placement within the biosciences with opportunities to develop business skills (Goddard *et al.*, 2023), improve academic performance (Gomez *et al.*, 2004) and enhance employability (Hejmadi *et al.*, 2012), this research presents a novel application of using a SaP approach to develop a student led peer-peer live fieldwork broadcast within the biosciences.

The placement experience was overall positive for all participants, with particularly enjoyable aspects relating to the team environment, providing new experiences, and seeing the results of the design process. More challenging aspects of the placement such as uncertainty and unpredictability of live broadcast, education development and logistics were not insurmountable and did not distract from the overall value of the placement. These challenges were addressed, with placement students identifying a range of knowledge-based skills, transferable skills, and personal attributes throughout the placement. More transferable skills were identified by students during the live fieldwork broadcast placement than knowledge based or personal attributes, this is in line with the work of Peasland *et al.* (2019), who found that the increased autonomy of student-centred fieldwork resulted in more transferable skills than staff-led fieldwork. Several of the skills developed and identified by students during the placement e.g., project management and communication, are identified as priority skills from employers to address the skills gaps in STEM and ecological careers (Wakeham Review, 2016; Bartlett and Gomez-Martin, 2017).

Additionally, more explicit links to graduate attributes and how courses of study can contribute to transferable skill development are recommended (Wong *et al.*, 2022) to help embed graduate attributes into specific programs of study (Jones, 2012). This placement provided that authentic opportunity with students developing transferable competencies in leadership and project management (CIEEM's Competency Framework, 2021), although it should be noted that much of these skills or attributes were self-reported by the placement students within this research.

The design of the placement promoted partnership values (Healey *et al*., 2016), which could be recognised in the student interviews. Although students have been involved in live broadcast work within HE (ChanLin, 2020; Reeves *et al.*, 2022) it is limited and (to the authors knowledge) none have used a SaP approach, with the student experience of this partnership work in live broadcast unexplored. Exploring partnership working is vital to create new spaces for collaboration and dialogue about teaching and learning (Healey *et al.*, 2016). This current research provides rich, detailed information about the student experience of working in partnership to co-produce a live fieldwork broadcast. It uncovers useful information on the value of doing so, and ways of working that promote partnership values. Digital fieldwork approaches have been identified as lacking in learner engagement (Barton, 2020) with them being less learner centred than their fieldwork alternatives (Stagg *et al*., 2022). The co-design process utilised in the production of the live fieldwork broadcast presents a way of actively involving learners in the co-creation of digital fieldwork content, with the partnership offering authentic peer-peer interaction and co-construction of knowledge. Partnership with students in curriculum design and pedagogic consultancy is not-well developed (Healey *et al.*, 2016). In evaluating #NclLive against UCL's Connected Curriculum framework (Fung, 2016), the live fieldwork broadcast placement provided opportunities for students to connect with staff and their research, connect academic learning with work place learning, connect students to each other and create student produced outputs.

Students defined their participation within the live fieldwork broadcast placement as 'students in control' and 'partnership- a negotiated curriculum' highlighting a shared responsibility between the placement students and the researcher/placement provider; this is identified as a key aspect of improving collaboration between teachers and learners (Könings *et al.*, 2021). The SaP approach within this current research can be conceptualised as both values based practice and counter-narrative (Matthews *et al.*, 2018) with the live fieldwork broadcast placement providing a mutually beneficial learning partnership and reducing power imbalances which have enabled new ways of engaging. However, existing power relationships outside of the immediate partnership of the live fieldwork broadcast were still present within student reflections on this placement, with power imbalances an ongoing area of challenge to continue to address in SaP work (Könings *et al.*, 2021).

The placement students recognised the value of live broadcast and could suggest future roles of live broadcast in fieldwork education and more broadly in practical science. The peer-peer live fieldwork broadcast model of working as presented within this research can be used to address some of the identified challenges of fieldwork (Cooke *et al*., 2020; Telford *et al*., 2023; Woodley et al., 2024). Firstly, partnerships with overseas institutions could enable fieldwork collaboration between countries tackling the cost, carbon and ethical issues of overseas fieldwork for undergraduates across disciplines (Smith, 2004; North *et al.*, 2020; Tooth and Viles, 2020; Telford *et al*., 2023). Secondly live fieldwork broadcasts between early-career researchers and undergraduates, could provide a cost-effective model of providing research-based fieldwork to enhance the teaching-research nexus (Griffiths, 2004), enhance teaching and learning as a whole (Fuller *et al.*, 2014) and provide engagement with the whole life cycle of research (Nicholson, 2011). This link between research and teaching is viewed favourably by both learners and academic staff, and can address issues of quality, diversity, and inclusions challenges within HE (British Academy, 2022).

In reflecting upon the live fieldwork broadcasts presented in this chapter through the SAMR lens (Puentedura, 2013), the two live fieldwork broadcasts developed as part of the co-production partnership are a 'Substitution', offering a direct switch with no functional improvement. However, the proposed future role of live broadcast in fieldwork presented in Figure 4.8 offers a 'Re-definition', where the technology allows for the creation of new tasks previously inconceivable.

4.6 Limitations and plans for the future

As in other chapters within this research, the reflexive thematic analysis conducted on the semi-structured interview data is open to researcher bias in the identification and interpretation of themes (see section 2.5). In extension of the co-production partnership adopted within the live fieldwork broadcast placement, three of the placement students (2022-2023 cycle) had been closely involved in reviewing the findings of this chapter by working to co-author a published paper and a vignette case study within a teaching focused textbook alongside the author of this piece of this research. This has enabled the findings of this chapter to be 'sense-checked' by the placement students themselves, ensuring a level of accuracy with the qualitative analysis. However, the reliability of these findings (as highlighted within Chapter 2) is likely to be limited, due to particular context factors which will have influenced the interpretation including the researcher's previous experience with live fieldwork broadcasting prior to undertaking this student co-produced version.

This research is a proof-of-concept study, providing a case study documenting the experiences of just five undergraduate placement students and one post-graduate researcher/placement provider through two cycles of a live fieldwork broadcast placement. However, it presents a model of working which can be replicated to produce a student-centred live fieldwork broadcast and shows appetite and opportunity for co-produced live fieldwork broadcast within existing fieldwork schemes of work, although the importance of context for the success of SaP work should not be ignored (Healey and Healey, 2018). Future research should use the schematics shared within this research to network the field environment, combining this with the logistics of running a student placement to replicate this study in other academic settings, which will add to the small evidence base on the use of live fieldwork broadcasting within the literature (Stagg *et al*., 2022; Brown *et al*., 2023; Open University, 2023). This replication should involve rigorous pre-and post-testing of skills, rather than relying on self-reported skill development as in this current research. This research outlines several other potential applications of live fieldwork broadcasts that remain untested. Future live fieldwork broadcasts should aim to test the feasibility and impact of these including connecting overseas research institutions with HE institutions, linking postgraduate researchers in the field with undergraduates and facilitating connections between learners conducting fieldwork in multiple locations. However before further developing these live fieldwork broadcasts, future research should focus on methods to increase viewer numbers and engagement. Due to the novelty of live broadcasting in fieldwork, this may require looking towards other applications of live streaming/broadcasting and live interactive polling for inspiration on appropriate approaches (Wang and Li, 2020; Lv *et al*., 2022) and investigating the suitability of these methods within the live fieldwork broadcast content. This would help to better understand the viewer experience and identify ways to improve the live broadcasts.

4.7 Summary

To the best of the authors' knowledge this research presents the first student co-produced live fieldwork broadcast in GEES or biosciences disciplines. It extends the literature on existing live fieldwork broadcast by presenting a low-cost, low-tech alternative to live broadcasting, offering a replicable model for other institutions. Several additional applications of live fieldwork broadcasts are suggested within this research.

The co-production partnership used to develop the live broadcasts presents a more enhanced approach to involving students in the design of digital tools, with the impact of this co-production partnership via a student placement shared within this research.

Although students identified elements of the live fieldwork broadcast placement were challenging including the education development process and the unpredictability of live broadcasting. There were enjoyable aspects including the sense of pride in the end result and working in the team environment. Throughout the placement, students developed and identified a range of skills, with over half of these transferable including decision-making, critical thinking, and leadership.

Chapter 5. Impact of a Digital Field Notebook (DFN) on fieldwork

Abstract

Although there are many functions of a mobile device that can be utilised during fieldwork, use of mobile devices during fieldwork is often guided by personal motivations, with many barriers to adoption. Digital field notebooks (DFNs) have been used within the geosciences and geography, earth, and environmental science (GEES) disciplines to collect and collate geospatial fieldwork data, yet despite the recognised value of spatial biological records the use of DFNs in the biosciences is currently under-utilised.

This research presents a DFN that aimed to address challenges associated with the disconnect between classroom and field, by supporting students' notetaking in the field using a digital device to collect and collate, geolocated observations. A pre-fieldwork survey and analysis of the DFN entries presents the impact of using a DFN during biosciences fieldwork. Focusing on student identified value of the DFN, its role in demonstrating student fieldwork skill competency and in fostering students' connection to nature.

Although students within this research identified value in using the DFN, with the features of this tool meeting their requirements, uptake for using the DFN during their fieldwork was extremely low. Students' DFN entries tended to focus on species that they were already confident with; suggesting students viewed the DFN as a tool to share rather than develop their species identification skills. Question prompts within the DFN offered the opportunity for students to showcase their observation skills. While students were able to describe a species, their responses did not demonstrate competent species literacy providing minimal interpretation of its broader connection to an environment.

Students demonstrated an understanding of the term nature connectedness, and there was no difference in students' pre-fieldwork Connectedness to Nature Scores (CNS) between the optional and the compulsory field trips; but there was a large range of CNS score within the sample.

Features of the natural landscape were more likely to be recognised by students as a 'good thing in nature' with the majority of students' landscape interpretation offering detailed description of the environment, highlighting the potential connection between landscape interpretation, nature connectedness and sense of place but further study is needed to better understand this relationship and the role the DFN plays in developing it.

Despite students recognising benefits of the DFN, in practice these benefits did not overcome barriers that students' face in using a DFN during fieldwork. This is a fundamental challenge that future research should seek to address to ensure a DFN can be integrated within biosciences fieldwork in HE.

5.1 Introduction

5.1.1 Use of DFNs in fieldwork

The value of notetaking within biosciences fieldwork has been historically important (Greene, 2011) and still remains a key feature of most fieldwork in Higher Education (HE) (Knapp, 2011) with learners encouraged to list objectives about the fieldwork, record date, time and locational information, draw diagrams, write descriptions about the site, record numerical data and make notes about the data (Lewis and Mills, 1995).

Ensuring field data are accessible and reproducible through digitisation (Wilkinson *et al*., 2016) can promote equitable fieldwork practice (Ramírez-Castañeda *et al*., 2022) with digital species records from field notes a useful and growing practice within biodiversity research (Nelson and Ellis, 2018).

This current research defines a Digital Field Notebook (DFN) as a catch all-term used to describe the use of a mobile device to collect both quantitative and qualitative data using in-built functions of the device and additional applications (apps). DFNs have been recognised as being useful within fieldwork by bringing together several fieldwork functions in one place with the additional abilities to geo-tag observations and the immediacy to present and analyse data within the field (France *et al*., 2015; Senger and Nordmo, 2021).

Mobile devices can be used in a variety of different ways within fieldwork, which support their use as a DFN. These can be summarised as:

• Existing functions- Simplistic use of existing functions of mobile devices such as camera, notes, and communication methods (Scanlon *et al*., 2005; Hein *et al*., 2011).

• Geolocation- The availability of GPS within mobile devices enables quantitative and qualitative data to be geo-located (Latham and McCormack, 2007; Welsh *et al*., 2012; Sebastián López and De Miguel González, 2020).

• Off-the shelf apps- These apps downloaded to mobile devices enable the device to be used as a measurement instrument and/or a tool for data collection, e.g., lux meters, decibel meters, annotating photos, and spatial biological records (France *et al*., 2016; Herbeling and Isaac, 2018; Cross *et al*., 2020; Callaghan *et al*., 2022; López-Guillén *et al*., 2024).

• Customisable apps- Apps that enable a user to personalise the function of the app to be suited to the purpose of their data collection, e.g., ArcGIS Field Maps (Bettinson and Bird, 2021; Phantuwongraj *et al*., 2021; Park, 2021).

• Species identification- Apps that use image recognition to identify species (Daume and Galaz, 2016; Katrak-Adeforowa *et al*., 2020; Perry *et al*., 2021).

• Specialist features- Some specific models of mobile devices have in-built features that are not present on all mobile devices on the market, e.g., LiDAR function of iPhone 14 (Tavani *et al*., 2022; Zizka *et al*., 2022).

Utilising apps on mobile devices is a quick and easy way to support learning within the field (Welsh *et al*., 2013, 2015) with opportunities to enhance the fieldwork via geo-location, communication, and collaboration with data exchange (France *et al*., 2016; Phantuwongraj *et al*., 2021; Xie *et al*., 2021).

A key affordance of using mobile devices within fieldwork include the saturation of mobile devices within the HE population. Learners have an ever-increasing access to a variety of smart devices at their disposal, with the percentage ownership of the following devices amongst learners within the UK (93% smart phone, 93% laptop PC and 67% tablet) (Collins, 2022). Such high levels of ownership support the recognised advantages of a 'Bring Your Own Devices' (BYOD) approach to fieldwork (Welsh *et al*., 2018; Clark *et al*., 2020). A BYOD approach coupled with institution led-digital poverty initiatives to tackle access and equity to devices means that the saturation of digital devices amongst learners in HE is high. Due to this saturation, mobile devices are a fieldwork technology that learners are already familiar with, requiring minimal onboarding to their use within fieldwork settings (Welsh *et al*., 2018), with learners themselves identifying that they know more about how to use mobile devices for learning than the academic teaching staff (Pearson, 2015). In general academics and learners use mobile apps in both teaching and research, yet uptake is determined by personal motivating factors and not institutional practice (Hinze *et al*., 2023). Although location-based functions of mobile apps have supported spatial thinking and understanding of fieldwork sites within geography, earth, and environmental science (GEES) disciplines

(Senger and Nordmo, 2021; Xie et al., 2021) this research seeks to extend this by considering the impact of planned DFN use within biosciences fieldwork at a single UK HE institution.

5.1.2 Demonstrating skill competency in fieldwork

Research on learning outcomes from undergraduate fieldwork focused predominately on the knowledge that learners gain, with less research on learners' skill development (O'Connell *et al*., 2018; Shinbrot *et al*., 2022). Skill development in fieldwork can be classified as technical (which is knowledge focussed and help learners to understand the subject), transferable (can readily be applied to other contexts) and personal attributes (more focused on the development of an individual and their personality) (Kent *et al*., 1997; Herrick *et al*., 2010; Peasland *et al*., 2019).

Species identification is a vital skill for learners in the biosciences, yet employers are concerned about a lack of species identification skills in HE graduates (IEEM, 2011; Bartlee and Gomez-Martin, 2017; Cooke *et al*., 2020). Fieldwork supports learner perceived outcomes in taxonomy and species identification (Scott and Boyd, 2014). According to The Chartered Institute of Ecology and Environmental Management Field Ecology Skills Guide graduates should be able to identify common plants and be able to identify common and indicator species from one or more taxonomic group, with habitat specialists expected to identify indicator species and be familiar with some of the less common species in that environment (Woods, 2007).

The use of mobile apps to support learners in the development of their species identification skills is a complex area with issues associated with misidentification (Pernat *et al*., 2023) and efficacy of the tools (Thomas and Fellowes, 2016). Yet learners have increased motivation to develop this skill area when using mobile apps (Jeno *et al*., 2017), and an increased opportunity for learners to engage with this skill development outside of allocated fieldwork teaching sessions (Thomas and Fellowes, 2016).

The DFN presented within this research is not a mobile application version of an identification guide, instead it offers students the chance to record and share their observations with their peers and facilitators of fieldwork, providing a digital copy of the species identification and the opportunity to seek support with their identification and address misidentification via asynchronous communication with peers and their facilitators of fieldwork. Although tools such as iNaturalist (iNaturalist, 2024) are used by ecologists to record and share observations, these are open-access, national data sets with prescribed data fields. This DFN offers a personalised and 'local' record of species during student field trips.

Observation skills were in the top five important fieldwork skills that learners acquire during fieldwork (Maw *et al.*, 2011), this key skill can be developed and applied outside of the subject of study (Wheeler *et al*., 2011). It has been identified that learners tend to recall and communicate field trip activities in which they were physically engaged in to a greater extent than activities in which they were passive observers (Nadelson and Jordan, 2012), with learners often missing key features of the environment during this observation if unprompted by facilitators (Kent *et al*., 1997). The DFN within this research is designed to offer these prompts to students, giving opportunities for students to demonstrate their observation skills via landscape interpretation and observations about individual organisms.

The *'placelessness'* of geoscience fieldwork has been explored and addressed using approaches that increase attachment to a location via learning more about a landscape, encouraging ownership and interaction with a location, which can support learner engagement (Apple *et al*., 2014; Jolley *et al*., 2018). Although this represents a geoscience context, in the biosciences, where learners are often focused only on identifying species or performing quantitative data collection tasks, it is not too far a stretch to suggest that these same issues could be present during fieldwork. Therefore, informed by the work of Bowser and Cid (2021), this research will consider how effective the DFN is in supporting the development of student observation skills during fieldwork with considerations of how these contribute to the development of students' sense of place in the fieldwork location.

5.1.3 Connection to nature during fieldwork

Nature connectedness relates to an individual's relationship and interconnectedness with the natural world (Nisbet *et al*., 2008) and can be determined subjectively by an individual (Pritchard *et al*., 2019) and quantified using measures such as the Connectedness to Nature Scale (Mayer and Frantz, 2004).

Fieldwork-based activities that HE learners undertake in the biosciences facilitate contact with nature. This supports learners' increased knowledge of nature through taxonomic skills and species identification (Maw *et al*., 2011; Scott *et al*., 2012). Understanding biodiversity in a location supports an individuals' attachment to that place (Horwitz *et al*., 2001). However, there is a need to also engage with nature in ways that support learners to move beyond these knowledge-based tasks which focus solely on identification, to a relationship which is more meaningful (Lumber *et al*., 2017). In a fieldwork context this could be in supporting learners to appreciate the environment that they are working in (Maw *et al*., 2011) or develop species literacy which considers the broader connection of species to help understand an environment (Hooykas *et al*., 2019). A meaningful relationship with nature has many benefits and is associated with pro-environmental behaviours and promoting positive wellbeing outcomes for an individual (Nisbet et al., 2009; Pritchard *et al*., 2019; Richardson *et al*., 2020a).

Connection to nature can be achieved by focusing on a *'pathways approach',* which supports connection via engagement with Senses, Emotion, Beauty, Meaning and Compassion (Richardson and Butler, 2022). Despite several outdoor learning and ecology-based organisations adopting the principles of the pathways to nature connectedness model, e.g., RSPB (Richardson *et al*., 2016) and National Trust (Richardson *et al*., 2020b), the majority of studies on nature-connection and learning focus on school-aged children (Lovell, 2016; Li and Sullivan, 2016) or within geography-based fieldwork in HE (Brookfield, 2021).

A disconnect with nature was identified as one of the emerging challenges of teaching and learning ecology for society (Cooke *et al.*, 2020), with some learners experiencing anxiety and stress in natural environments (Dillon *et al*., 2006; Boyle *et al*., 2007). Interestingly however, progressive, and supported introduction to these environments via field trips was not identified as a solution to address this (Cooke *et al*., 2020), despite an understanding of a landscape key to supporting a sense of place (Drenthen, 2011) and connection to nature (Newman and Dale, 2013). This presents an opportunity for this research to consider the role of fieldwork in supporting nature connection within the context of biosciences fieldwork in HE. Addressing this disconnect is particularly relevant in light of Covid-19 and the global response, which have altered how people interact with nature (Soga *et al*., 2021). Three key changes; opportunity, capability, and motivation for human-nature interaction; have been identified (Soga *et al*., 2021). The DFN offers the potential to enhance capability and motivation by adopting a 'gamified' approach that encourages users to document their interactions and develop species identification skills.

with this research contributing to assessing students connection to nature

Tools that intentionally support learners' connection to nature have been explored in online, virtual environments (Race *et al*., 2021; Mercer *et al*., 2023) and include using green micro-breaks and immersive soundscapes to support nature connectedness. Yet learners in other studies have reflected upon the 'digital nature disconnect' when learning online in virtual environments (Bacon, 2023).

Digital technologies influence peoples' relationship with nature via big-data collation and sharing experiences in nature (Arts *et al*., 2015). Yet mobile device use during fieldwork is a complex issue, with their use presenting both as a distractor in the field (France *et al*., 2016; Derounian, 2017; Thomas and Munge, 2017) and on-task use enhancing existing fieldwork practice (Sebastián López and De Miguel González, 2020; Bettinson and Bird, 2021; Zizka *et al*., 2022). Research suggests that nature connectedness is positively related to the number of nature pictures taken per week yet negatively related to overall smartphone usage (Richardson *et al.* 2018).

What emerges is an opportunity to consider the impact of using technology to support the embedding of nature connection principles in biosciences fieldwork in HE. The DFN was designed to support on-task, purposeful mobile device use, as the use of mobile devices to support students' connection with nature in biosciences fieldwork is currently unexplored.

5.1.4 Research aim and objectives

The overarching research aim (RA) of this chapter is to identify the impact of using a digital tool (Digital Field Notebook (DFN)) during fieldwork (RA4). To address this aim, this chapter will focus on three research objectives (RO). First, this research will consider if students identify value in using a DFN during biosciences fieldwork in HE (RO4.1). Second, does the DFN provide an effective method for students to demonstrate their competency in a range of fieldwork skills (RO4.2). Finally, does a DFN support students' connection to nature during fieldwork (RO4.3).

5.2 Context underpinning the research

The DFN was designed to address the challenges associated with the disconnect between classroom and field, by supporting students' notetaking in the field, and offering opportunities to foster students' connection to nature during fieldwork.

A workflow schematic shows how the DFN was constructed and the specific roles that students and facilitators performed to enable the DFN to operate (Figure 5.1). It also identifies how information is transferred, collated, and presented (Maddison *et al*., 2023a).

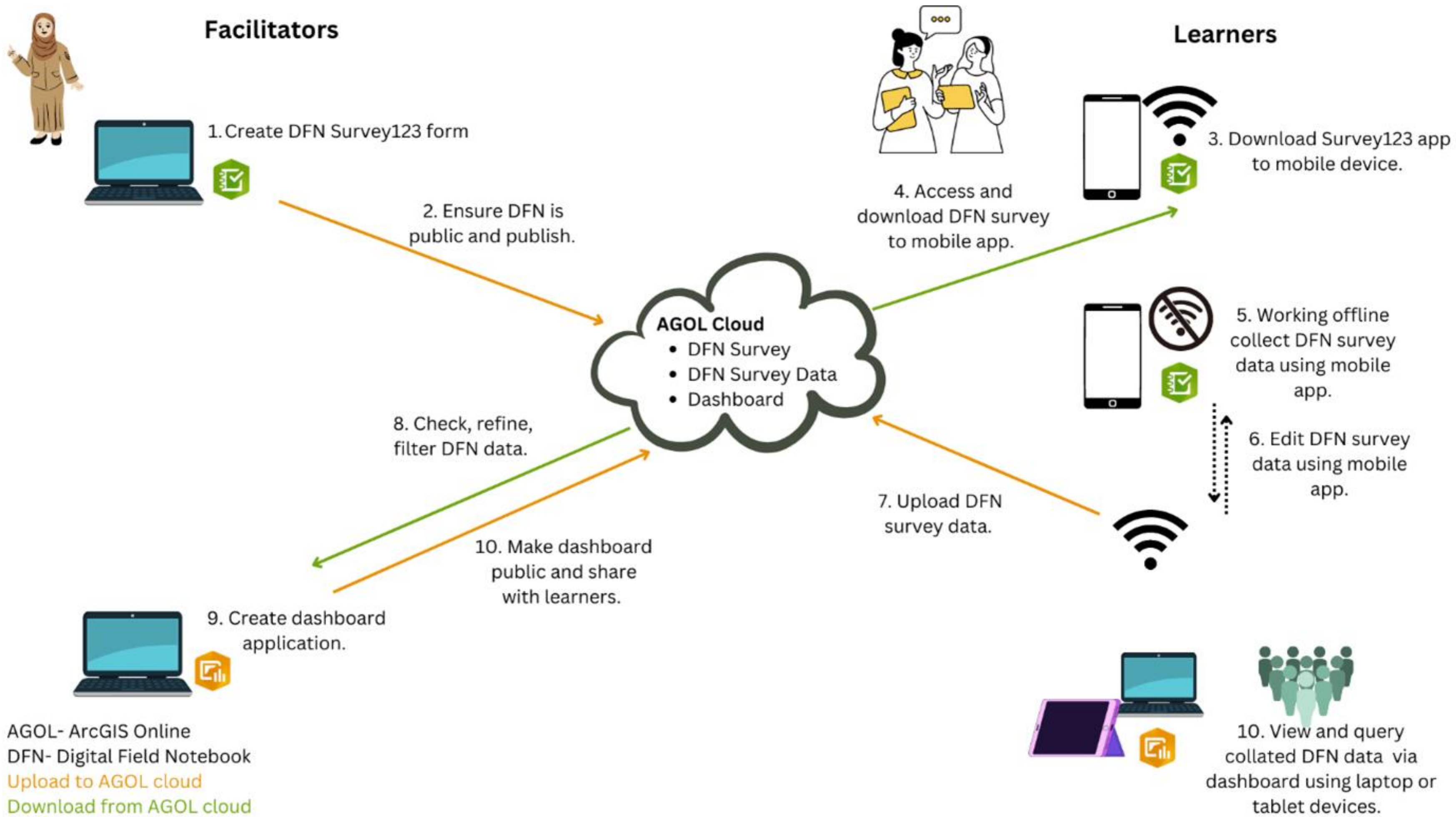

Figure 5.1 Workflow schematic of the Digital Field Notebook (DFN) detailing the use of ArcGIS Online (AGOL), ArcGIS Survey123 and ArcGIS Dashboards. The roles of learners and facilitators are defined as well as how information is uploaded (orange) and downloaded (green) from AGOL cloud (Maddison et al., 2023a).

5.3 Methods

5.3.1 Recruiting participants

The DFN was introduced to two groups of students undertaking fieldwork at Newcastle University, with Table 5.1 sharing whether the fieldwork was a compulsory or optional component of their degree. Each group of students was given a short briefing on the DFN, which included guidance on how to download ArcGIS Survey 123 app, how to access and download the DFN to work offline during fieldwork. In this briefing, students were also given access to a participant information sheet (Appendix 5.1), which gave potential users of the DFN, information on the purpose of this research. This research received ethical approval Ref: 21749/2022.

Table 5.1 Summary of the fieldwork courses that the Digital Field Notebook (DFN) was introduced and used within.

	Course	**Fieldwork activity**	**Stage**	**No. of student**	**Fieldwork requirement**
1.	Marine Practical Skills.	Local day fieldwork.	First year undergraduate.	67	Compulsory.
2.	Field-based Ecology: designing experiments and residential field course.	Residential fieldwork.	Second year undergraduate.	60	Optional.

5.3.2 Pre-fieldwork survey

Prior to undertaking the fieldwork in Table 5.1 all students were contacted with a link to a survey designed to be completed prior to completing fieldwork. The majority of students completed the survey during a timetabled pre-fieldwork session after the initial briefing on the DFN had been completed.

This anonymous survey was hosted by JISC Online Surveys. Within the pre-fieldwork survey students were asked to provide consent prior to completing and committing the survey. Anyone not giving consent was screened away from the survey.

A mix of open and closed questions were included in the survey, with all questions optional (Appendix 5.2). The survey aimed to uncover information on several areas. Firstly, students were asked to share their views of both notetaking in the field and the use of the technology in fieldwork. These data were collected to answer RO4.1; value of a DFN, as it provided evidence of students' views prior to using the DFN. Secondly, students self-reported competency of several fieldwork skills (applying theoretical knowledge, observation, reflection, global positioning service (GPS)/geographical information systems (GIS), identifying/describing habitats, explaining natural processes and identifying organisms) was gathered using a four-point Likert scale *('1. Not at all skilled- cannot or never performed before', '2. Not very skilled- can perform with guidance', '3. Somewhat skilled- can perform independently but require guidance at some times', '4. Skilled- can perform independently'*). These seven fieldwork skills were identified by a review of the module outline form for each fieldwork element that the students were undertaking and from the authors own experience of the fieldwork undertaken by the students.

These data were collected to answer RO4.2; DFN as a method for students to demonstrate fieldwork skill competency, as it provided students with the opportunity to self-report their competency prior to using the DFN. Thirdly, students were asked to demonstrate their understanding of the term 'nature connectedness' by providing their own definition of the term. Students also completed a 14-item Connectedness to Nature Scale (CNS) (Mayer and Frantz, 2004) where they reviewed statements on a five-point Likert scale *('1. Strongly disagree', '2. Disagree', '3. Neutral', '4. Agree', '5. Strongly agree')*. The CNS is designed to measure students' emotional connection to the natural world and has been used in a range of academic studies assessing nature connectedness (Perrin and Benassi, 2009; Pasca *et al*., 2017; Lovati *et al*. 2023) and is recommended for use by fieldwork and outdoor facilitators (Salazar *et al*., 2020). Both the definition and CNS scores were used to answer RO4.3; DFN supporting students' connection nature, as it provided a quantitative measure of students' nature connectedness prior to using the DFN, as well as a measure of students understanding of nature connectedness.

5.3.3 DFN entries

The analysis and evaluation of the content of field notebooks have been used to identify learner skill development (Peasland *et al*., 2019), provide insight into learner affect (attitudes and emotions) (Treibergs *et al*., 2022) and for assessing learner understanding (Chua *et al*., 2020). This research will seek to use the content of student DFNs to evaluate students' competency of a range of fieldwork skills and as a measure of their connection to nature.

Prior to embarking on fieldwork, students were encouraged to use the DFN to record their fieldwork observations. The DFN was designed to be complementary to the fieldwork that the student was undertaking. It provided prompts for students to input fieldwork observations on the following aspects:

- Species identification: Name of species, confidence in identification, habitat type and photo of organism.
- Landscape interpretation.
- Nature connectedness: Three good things in nature (Richardson *et al*., 2015), share something that has brought you joy during fieldwork, categorise mood experienced (adapted from Brackett, 2024).

To ensure students were aware of where submitted data were stored, and who would have access to it, the first page of the DFN included a privacy notification with link to the participant information sheet. Appendix 5.3 shows screenshots of the five-page user-interface for the DFN.

As this research was designed to capture the impact of using a DFN during fieldwork, focusing on its use as a tool for students to demonstrate competency in fieldwork skills and support students' connection to nature during fieldwork, students' engagement and use of the DFN offered an indirect measure of RO4.1, students' value of using a DFN during biosciences fieldwork. As direct measures of the impact of the DFN on students' nature connectedness and competency in fieldwork skills were not available, DFN entries were used as a proxy to evidence RO4.2; 'Does the DFN provide an effective method for students to demonstrate their competency in a range of fieldwork skills?' And for RO4.3; 'Does a DFN support students' connection to nature during fieldwork?'

5.3.4 Data analysis

This research produced quantitative and qualitative data from both a pre-fieldwork survey and the DFN entries. Table 5.2 summarises the data collection methods used pre-fieldwork and during the DFN alongside the data analysis undertaken, and how it related to each of the research methods and research objectives.

Table 5.2 Summary of the survey questions and data analysis undertaken within this research and how it relates to each aspect of the method and research objectives (RO).

ROs	Pre-fieldwork survey		Questions in the Digital Field Notebook (DFN)	
	Survey question	**Data analysis**	**Survey question**	**Data analysis**
Do students identify value in using a DFN during bioscience fieldwork? (RO4.1).	*'When conducting fieldwork list the things that you think are important to record when out in the field.'*	Inductive content analysis on student responses to determine frequency of identified themes within student responses. Descriptive statistics to determine frequency (%) of responses. Data inputted into an online word cloud generator (https://wordart.com/) to produce a visual representation of qualitative data that give greater rank to	Features of the DFN.	The features of the DFN were reviewed against student response outputs to the question; 'When conducting fieldwork list the things that you think are important to record when out in the field.'

		words that appear more frequently.[1] Using the results of the inductive content analysis (frequency of themes from student responses to the things important to record when out in the field, Principal Component Analysis undertaken to determine which of the high frequency themes can be attributed to the driving forces of degree choice (‘Biology’, ‘Zoology’, ‘Marine Biology’, ‘Marine Zoology’), or whether other factors are important in driving what students think is important to record during fieldwork.[2]		

	'Do you see value in using technology in the field? Please explain your answer.'	Inductive content analysis on student responses to determine frequency of identified themes within student responses. Using the results of the inductive content analysis (frequency of themes from student responses to; yes I do see value in the use of technology in the field) Principal Component Analysis undertaken to determine which of the themes can be attributed to the driving forces of degree choice ('Biology', 'Zoology', 'Marine Biology', 'Marine Zoology'), or whether other factors are important in	Engagement metrics with specific questions in the DFN and overall DFN use.	Calculations of response rate (%) for each individual question for each section of the DFN.

		driving students identified value in using technology in field.[2]		
Does the DFN provide an effective method for students to demonstrate their competency in a range of fieldwork skills? (RO4.2).	*'Do you think technology in the field can be used to enhance your fieldwork knowledge and skills?'*	Descriptive statistics to determine frequency (%) of responses.	Species identified and confidence of students' identification of the species using a five-point scale.	Descriptive review of students species identification skill.
	'In what ways can technology in the field be used to enhance your fieldwork knowledge and skills? Please explain your answer.'	A skills framework (Peasland *et al.*, 2019) was applied to this data and used to classify the skills identified by students.	(A) 'Description- Share any unique information about this organism, its behaviour or the habitat it is in'. (B) 'Describe any patterns or features you can observe in the environment'.	Deductive content analysis undertaken to determine frequency of occurrence of pre-determined codes in the data. Two coding frameworks based on assessment rubrics: (A) Behaviour, Morphology, Distribution in Environment. (B) List features present, Detailed description,

				Specialised vocabulary used, Interpretation offered.
	Student self-reported competency of seven fieldwork skills recorded using a 4-point Likert scale.	Descriptive skills to determine frequency (%) of responses. A Schreier-Ray-Hare test was undertaken to determine whether student responses to the self-reported competency of fieldwork skills was affected by individual skill type and/or overall skill area (knowledge based or transferable).[4]	Consider what physical processes and human impacts are having the biggest impact in this environment' and to explain why.	Reflexive thematic analysis to identify themes in student responses. [2]
Does a DFN support students' connection to nature during fieldwork? (RO4.3).	*'What does the term 'Nature Connectedness' mean to you?'*	Reflexive thematic analysis to identify themes in student responses. [3] Deductive content analysis (using the main themes identified from the reflexive thematic analysis)	Three good things in nature' 'How did these three good things in nature make you feel?'	Data inputted into an online word cloud generator (https://wordart.com/) to produce a visual representation of qualitative data that give greater rank to words that appear more frequently[1].

		on student responses to determine frequency of identified themes within student responses. Principal Component Analysis undertaken to determine which of the themes can be attributed to the driving forces of degree choice, or whether other factors are important in driving students definitions of nature connectedness.[2]		Inductive content analysis undertaken to determine frequency of occurrence of codes that were identified from the data.
	Student Connection to Nature Score where students select the extent to which they agree or disagree with a 14-item survey on a 5-point Likert scale.	Responses to each item on the survey are assigned a score (-2, -1, 0, 1, 2). A total is calculated. The higher the score, the higher the nature connectedness.	'Share something that has brought you joy and wonder at this location?	Inductive content analysis undertaken to determine frequency of occurrence of codes that were identified from the data.

	Several statements are reverse scored (see Appendix 5.2) (Mayer and Frantz, 2004)	Distribution of CNS scores analysed. Mann-Whitney-*U* test undertaken to determine if there is a significant difference between the median CNS scores between first year Marine Biology/zoology Undergraduates and second year Biology/zoology undergraduates.[4]		

[1] Several processes to clean the data were undertaken prior to constructing the word cloud. These included spelling variations reviewing and grouped (temperature and temp); common non-specific words removed (e.g., and, if, or); some grouping of synonyms undertaken (species and organisms).

[2] This statistical analysis was undertaken using PRIMER 7 (PRIMER-E, Plymouth, 192pp. v7: Clarke, KR, Gorley, RN, 2015. PRIMER v7: User Manual/Tutorial. PRIMER-E, Plymouth, 296 pp).

[3] Several instances of reflective thematic analysis were conducted within this research. These were all carried out independently on each of the data sets using six-stage analytical guidance (Braun and Clarke, 2019; 2020) where the researcher is actively involved in producing themes from

the data. Themes and any sub-themes presented within this research represent what participants have communicated within the research, but I acknowledge the role that the author as researcher plays in constructing those themes during the data analysis process.

[4] This statistical analysis was undertaken using SPSS (IBM SPSS Statistics for Windows, version 29.0.1.0 (171) (IBM Corp., Armonk, N.Y., USA).

5.4 Findings

5.4.1 Identifying value in the use of a DFN

The DFN was introduced to two groups of students (n = 127) who were undertaking fieldwork as part of their bioscience degrees. Of these, 107 students completed the pre-fieldwork survey, with an even split between first year (51%) and second year (49%) undergraduate students. Forty-four percent were undergraduates on a marine biology degree, 27% were undergraduates on zoology degree, 21% were undergraduates on biology degree and 7% were undergraduates on marine zoology degrees.

During the pre-fieldwork survey students were asked to share their response to the following question: *'When conducting fieldwork list the things that you think are important to record when out in the field.'* Inductive content analysis on student responses was used to determine the frequency of themes summarising participant responses. Figure 5.2 summarises the top ten highest frequency student identified things to record when out in the field, with Figure 5.3 providing examples of student responses.

The species found during fieldwork was the highest frequency response to this question, with 61 of responses mentioning that recording species was important (Figure 5.2; Table 5.3). With other students sharing the importance of recording measures of species diversity (Figure 5.2; Table 5.3). Conditions of the fieldwork site was the second highest frequency response, with it being listed in 42 responses. Students also cited the importance of recording the weather during fieldwork, with this being listed in 35 of responses (Figure 5.2; Table 5.3). Data was the fourth highest frequency response with it being listed in 31 responses with students identifying that recording quantitative data was an important thing to record during fieldwork with specific examples given (Figure 5.2; Table 5.3). Observations was listed in 28 responses and was the fifth highest frequency response (Figure 5.2; Table 5.3). Information about the site and the fieldwork including location, time, date as well as description of the environment and habitat (Figure 5.2; Table 5.3).

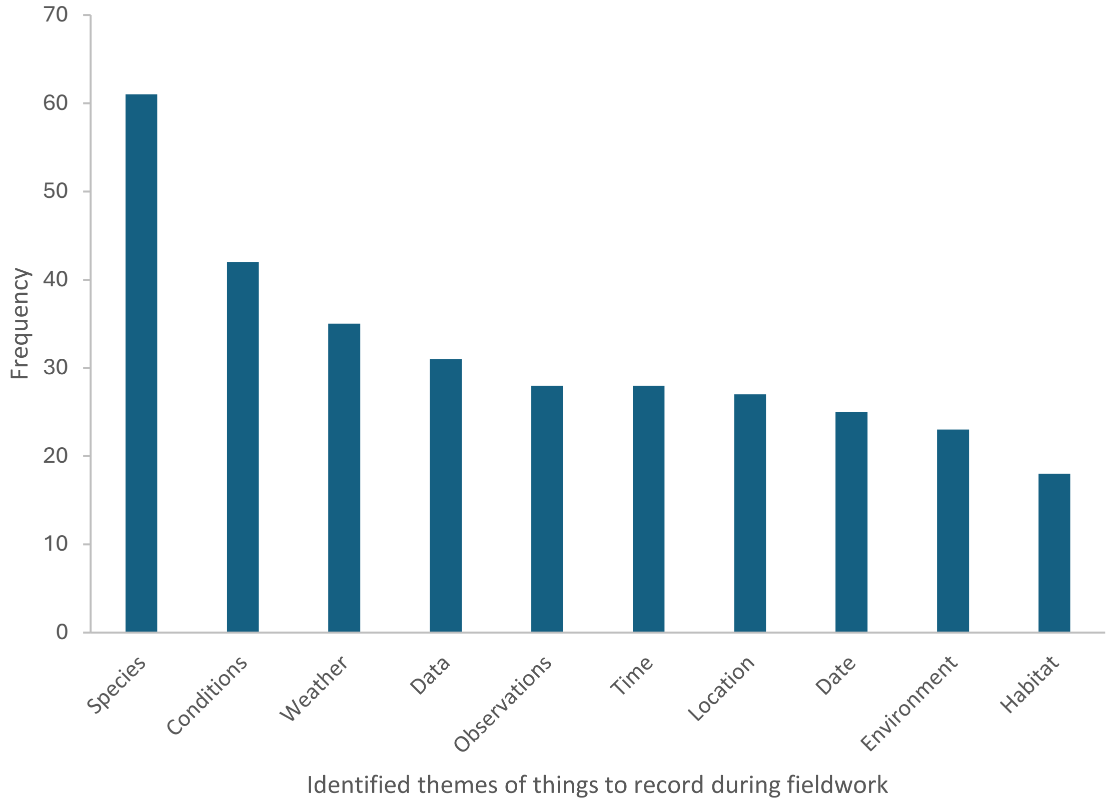

Figure 5.2 Top ten highest frequency student responses to the question 'When conducting fieldwork list the things that you think are important to record when out in the field.' (n = 107).

Table 5.3 Student quotes to illustrate the factors that students identified as being important to record when out in the field.

Factor	Student quote
Species.	*"Species found, abundance/distribution in different parts of the field." S64*
	"Observations such as species richness and diversity." S92
	"Species richness/ evenness." S130
Conditions.	*"Environment conditions and other factors that could affect the data outcomes/recordings" S101*
	"Temperature and weather. Anything different that affects your ability to do what you planned." S144
	"Possible influences on results (e.g. weather)." S109
Data.	*"Sample size measurements statistics." S118*
	"Distance from certain factors e.g. shore, roads., temperature, salinity, pH, (and) moisture." S106
Observations.	*"Observations of anything that might affect the data collected." S144*
	"Observations of organisms and their habitat." S57
	"General observations about the environment and climate." S120
Information about the site.	*"The ecosystem you're working in. The species present. The time of year. The conditions, weather, day/night. The location." S140*

A Principal Component Analysis (PCA) was undertaken on the results of the inductive content analysis of the student responses to *'When conducting fieldwork list the things that you think are important to record when out in the field? '*to determine which of those high frequency themes in Figure 5.2 can be attributed to the driving forces of degree choice ('Biology', 'Zoology', 'Marine Biology', 'Marine Zoology', or whether other factors are important in driving what students think are important to record during fieldwork. The PCA revealed the presence of three components with Eigenvalues exceeding 1, which accounted for 100% of total variance (Table 5.4). The PCA plot (Figure 5.3) shows that degree choice did drive student themes related to the things students thought were important to record during fieldwork. The themes 'Species', 'Habitat', 'Observations', 'Environment', 'Conditions' and 'Weather' were driven by the degree choice of marine biology. Alternatively, the themes 'Date', 'Time', 'Data' and 'Location' were driven by the degree choices of zoology and biology. This perhaps reflects the nature of the undergraduate teaching on these different degree programmes with the marine students undertaking specific qualitative fieldwork sessions focussed on observation, species drawings and taxonomy, compared to zoology and biology students whose fieldwork could be described as being solely hypothesis and data driven. Another reason behind this distinction could also be the difference in scale between the fieldwork for these students within marine fieldwork and fieldwork for zoology and biology students. Fieldwork for the marine biology and marine zoology students often worked within microhabitats within a smaller area e.g. different shore heights on a particular rocky shore. As such the habitats and environmental conditions at these sites is an important factor to record while zoology and biology students may look over several different habitats or ecosystems and as such location was more important.

Table 5.4 Principal Component Analysis (PCA) values identifying three principal components of the high frequency themes of 'What should be recorded during fieldwork?' and degree choice.

Principle component	**Eigenvalue**	**% Variation**	**Cumulative % Variation**
1.	5.17	51.7	51.7
2.	3.36	33.6	85.3
3.	1.47	14.7	100

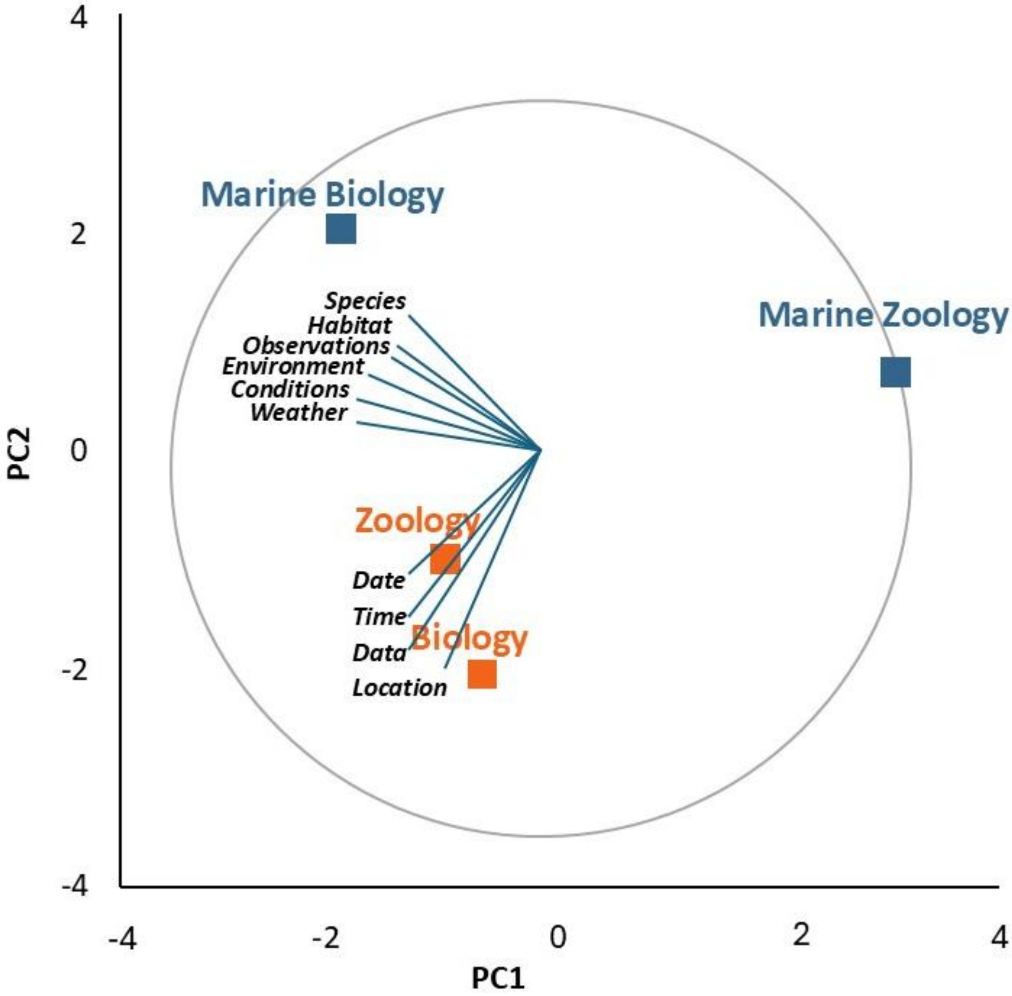

Figure 5.3 Principal Component Analysis (PCA) plot to show which of the high frequency themes of 'What should be recorded during fieldwork?' can be attributed to degree choice.

Of the top ten highest frequency items that students identified as important to record, (Figure 5.2), the DFN was designed to collect eight out of the ten of these items (Species, Conditions, Observations, Time, Locations, Date, Environment and Habitat) (purple words in Figure 5.4). Only ‘data’ and ‘weather’ were items identified as important by students that the DFN did not enable students to collect in the field (orange words in Figure 5.4). Overall, the DFN enabled students to effectively record the majority of things that they thought were important to record during fieldwork.

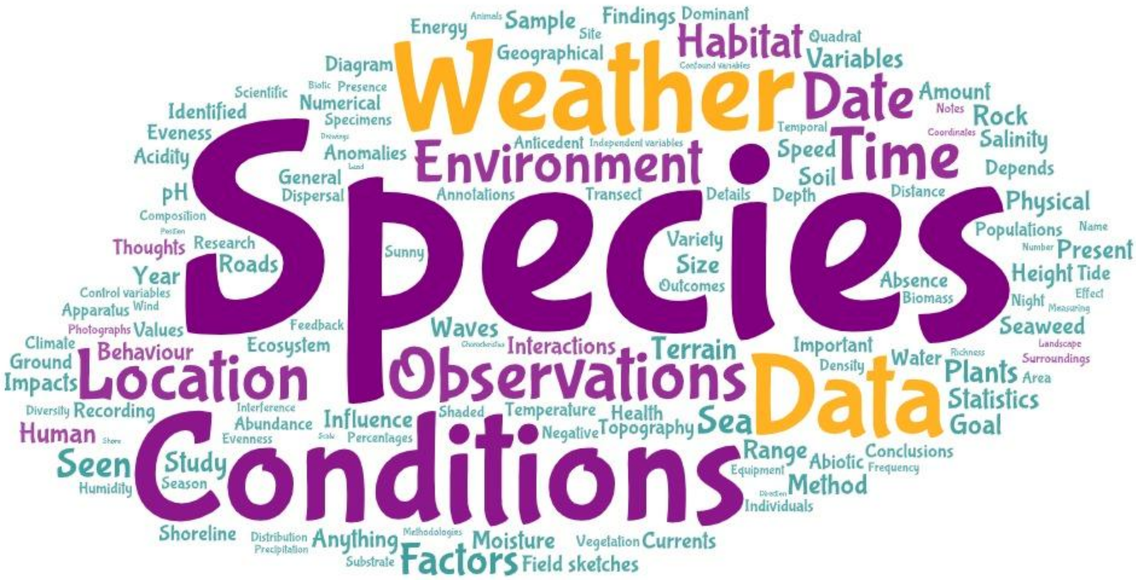

Figure 5.4 Qualitative student responses to the question 'When conducting fieldwork list the things that you think are important to record when out in the field.' Higher frequency items are displayed in larger text in the word cloud. Items that the Digital Field Notebook (DFN) records are displayed in purple. Items from the top ten highest frequency student responses that are not recorded in the DFN are displayed in orange. Common words e.g., 'and' are removed. Some grouping of synonyms has been undertaken e.g., species and organisms. Spelling variations are reviewed and grouped e.g., temp and temperature.

Of the 107 students who completed the survey 94% (101 out of 107) saw value in using technology in fieldwork, with five students unsure, and one student identifying that they did not see value in using technology in fieldwork. When students were asked to explain their position on the value of technology in fieldwork, using inductive content analysis 14 themes were identified in the data (Figure 5.5). Table 5.5 uses student quotes to illustrate the themes identified.

Figure 5.5 Summary of the results identified from the inductive content analysis of 'yes' student responses to the pre-fieldwork survey (n = 101) 'Yes, I do see value in using technology in the field. Please explain your answer.'

Table 5.5 Student quotes to illustrate themes identified from the reflexive thematic analysis of student responses to 'Yes, I do see value in using technology in the field. Please explain your answer.'

Theme	Student quote
Efficiencies.	*"It can increase efficiency when taking notes. It also provides one place where data is stored which makes it easier to look back at." S54*
	"Quicker than typing up paper, more convenient as less likely to get lost. Will already be carrying device." S136
Advance observations.	*"Taking photos and being able to annotate them." S89*
Digital at point of capture.	*"It has advantages that make data collection easier, such as uploading results to an online cloud." S145*
	"Can be easier to store, protect and share data." S147
Sharing data.	*"It would improve my ability to create more useful notes in the field rather than just relying on myself." S64*
	"It can collate data quicker than I can with more accuracy." S91
	"Any information recorded can also be synced and shared easily with others." S63
GIS.	*"With media and geolocation fieldwork can be more accurately recorded and more organised." S71*
	"Used ArcGIS before in geography A Level and it was a great tool, would love to use again in marine work." S42
Address human error.	*"Can help provide more accurate data." S52*
	"Technology compensates for the errors with handwritten notes." S71
	"Use of technology in the field is generally conducive to more accurate/better quality results." S109

Organisation and logistics.	*"Could be good to keep things neat." S85*
	"More accurate, less messy." S75
	"Technology can be useful for keeping notes organised and permanent as paper can be lost and damaged!" S86

One of these themes **'**Efficiencies' reflects students' views that technology is a time-saving tool when collecting fieldwork data. Students shared their reasons for these efficiency savings (Table 5.5). Technology also added value to fieldwork notetaking by advancing the notes that students made by enabling the recording of photos and video (Table 5.5). Using technology means that data was 'digital at point of capture' and this was identified as something that had value when using technology in fieldwork (Table 5.5). This sharing of data was seen as a specific value to the use of using technology in the field, meaning that notes could be shared between all members of a fieldwork group or cohort (Table 5.5). Another value of technology in the field identified by students was its relationship with GIS (Table 5.5). There was a view from students that the use of technology improved data collection in fieldwork by reducing human error and improving accuracy and reliability of the data (Table 5.5) as well as value associated with 'neatness' and 'organisation' of notetaking and data collection (Table 5.5).

A PCA was undertaken on the results of the content analysis of the student responses to *'Yes, I do see value in using technology in the field. Please explain your answer'* to determine which of those high frequency themes in Figure 5.5 can be attributed to the driving forces of degree choice ('Biology', 'Zoology', 'Marine Biology', 'Marine Zoology'), or whether other factors are important in driving what students think is the value in using technology during fieldwork. The PCA revealed the presence of three components with Eigen values exceeding 1, which accounted for 100% of the total variance (Table 5.6). The PCA plot (Figure 5.6) shows that degree choice did drive student themes related to the value of technology in fieldwork with the majority of the identified themes associated with the degree of marine biology, showing that the students who are studying marine biology had a broad understanding of the value of technology in fieldwork. This could be explained by the undergraduate teaching on this programme, with virtual fieldwork environments embedded within the marine biology programme. The theme 'Evaluate large secondary data sets' was a factor largely driven by the degree choice of biology, again this could be explained by the undergraduate teaching on this programme, with desk-based fieldwork alternatives available for students which focus on the analysis of secondary data.

Table 5.6 Principal Component Analysis (PCA) values identifying three principal components of the themes 'value of technology in fieldwork' and degree choice.

Principle component	**Eigenvalue**	**% Variation**	**Cumulative % Variation**
1.	9.53	68.1	68.1
2.	2.86	20.4	88.5
3.	1.6	11.5	100

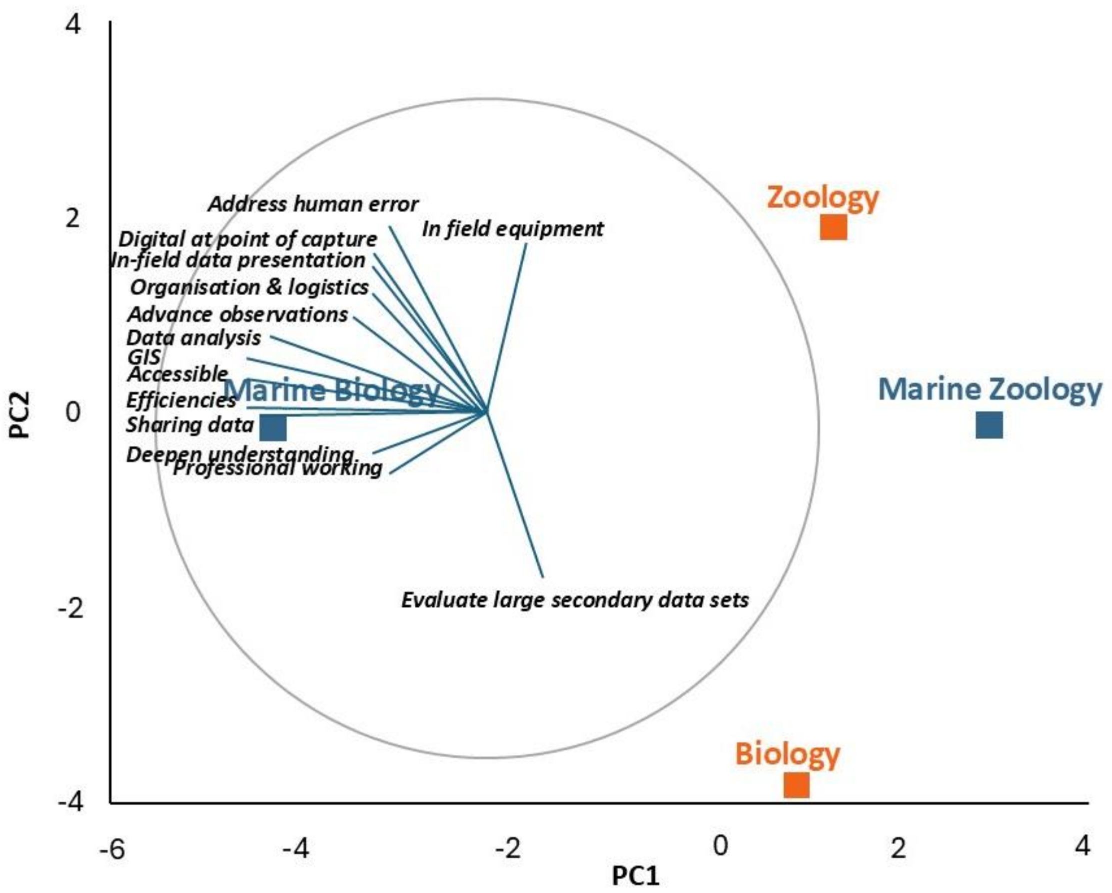

Figure 5.6 Principal Component Analysis (PCA) plot to show which of the themes of 'value of technology in fieldwork' can be attributed to degree choice.

Of the six students who were unsure or did not see value in the use of technology in fieldwork, some of the comments highlighted student unfamiliarity with the use of technology in fieldwork and that technology itself could prove distracting when conducting fieldwork (Table 5.7).

Table 5.7 Student quotes to illustrate themes identified from the reflexive thematic analysis of student responses to 'No, I do not see value in using technology in the field. Please explain your answer.'

Theme	Student quote
Unfamiliarity with technology.	*"I am not sure because I have not used much technology before." S76*
	"First time hearing about it, seems promising, but I want to try it before saying yes/no." S138
Distractor.	*"I sometimes find that having so many apps can over complicate things and I don't feel like I have any issues making notes in the field currently." S50*
	"Devices can get wet and damaged, there may be technical difficulties when you are mid-note taking and miss valuable information." S62

In the pre-fieldwork survey (n = 107) students overwhelmingly identified value in the use of technology in fieldwork, specifically highlighting the role of digital notetaking for efficiency and in collaborating. In practice however students did not readily use the DFN for fieldwork notetaking, with only 43 entries added to the DFN; highlighting a difference between students perceived and realised value in a DFN within fieldwork in the biosciences. As all questions were optional, all 43 entries did not add data for each question. Table 5.8 summarises the number of submitted responses for each question in the DFN, it also identifies the mean response rate (%) for each section of the DFN.

Table 5.8 Number of submitted responses for each of the optional questions in the Digital Field Notebook (DFN). Response rate (%) for each question is calculated based on total number of unique entries (n = 43), with mean response rate calculated for each section of the DFN.

Section	**Specific data**	**Number of responses**	**Response rate %**	**Mean response rate %**
Species Identification.	Species name.	31	72	**68**
	ID confidence.	33	77	
	Habitat.	36	84	
	Photo of organism.	25	58	
	Description- Share any unique information about this organism, its behaviour or the habitat it is in.	22	51	
Landscape Interpretation.	Describe any patterns or features you can observe in the environment.	27	58	**62**
	Consider what physical processes and human impacts are having the biggest impact in this environment. Why?	28	65	
Nature Connection.	Beauty- Record three good things in nature that you can see.	29	67	**65**
	Meaning- How did these three good things in nature make you feel?	33	77	
	Emotion- Share something that has brought you joy and wonder at this location.	22	51	

There was a similar response rate for all three of the sections of the DFN; Species Identification (68%), Landscape Interpretation section (62%) and the Nature Connection (65%).

The four individual questions with the lowest response rate were *'Emotion- Share something that has brought you joy and wonder at this location'* (51%); *'Description- Share any unique information about this organism, its behaviour or the habitat it is in'* (51%), *'Take or upload photo of organism'* (58%) and *'Describe any patterns or features you can observe in the environment.'*

5.4.2 Using the DFN to demonstrate the development of fieldwork skills

Ninety-two percent of students (98 out of the 106) shared they thought that technology in fieldwork could be used to enhance fieldwork knowledge and skills, with seven students unsure, and one student identifying that they did not think that technology in fieldwork could be used to enhance fieldwork knowledge and skills.

For those students who answered yes (92%) they were then asked in what ways can technology in the field be used to enhance your fieldwork knowledge and skills. Informed by Peasland *et al*., (2019) skills were categorised into knowledge-based skills, transferable skills and those skills which were personal attributes (Figure 5.7) with student quotes used to illustrate these skills (Table 5.9).

Figure 5.7 Student identified skills of using technology in fieldwork in the pre-fieldwork survey (n = 107). Skills were categorised into knowledge-based skills, transferable skills and personal attributes.

Table 5.9 Student quotes to illustrate the identified skills (classified as transferable, knowledge-based and personal attributes) of using technology in fieldwork.

	Skill	*Student quote*
Transferable.	**Interpersonal skills- team management, communication and collaboration.**	*"It can be more collaborative." S132*
		"Online resources, people collaborated, would be a valuable reference." S71
		"Technology can be used to enhance note taking, data management, team management and communication through things such as tablets to reduce the space of notetaking. Apps to compile teams of data." S49
	Presentation and data analysis.	*"It can be used to create accurate graphs or tables and work out equations quicker." S118*
		"Create figures such as graphs etc to support my work." S74
Knowledge.	**In-field research skills.**	*"If you don't know something there and then you can quickly research it." S115*
		"You can look up more information while out in the field if you're unaware of something." S110
		"I could look up things I forget or use it to find pre-recorded data." S94
	Species identification.	*"You are able to find out more about a species at that moment." S52*
		"Can help with identifying things in the field and recording them easily." S63
		"Allows access to new tools and information quickly - can help identify organisms or processes without the help of an expert." S77
	Spatial and GIS.	*"Better spatial awareness of data." S42*
		"Monitoring, mapping, tracking." S117

		"By using software such as GIS it can help me understand my findings." S143
		"It can help correlate different patterns and relate spatial and temporal components." S134
Personal attributes.	**Critical thinking.**	*"It allows for my time thinking about what you have found rather than collecting that information." S78*
	New ways of thinking.	*"Work out ways to do things that you hadn't thought of." S101*

Half of all the skills that students identified were transferable. There were six transferable skills that students identified could be developed by using technology in the field. Three of these skills (team management, communication, and collaboration) could be classified as developing students' interpersonal skills (Table 5.9). Presentation and data analysis skills were also a transferable skill that could be developed using technology in the field (Table 5.9). There were four knowledge-based skills that students identified that could be developed from using technology in the field: i) use of technology to develop in-field research skills; ii) species identification; iii) spatial skills; and iv) GIS skills (Table 5.9). Students identified that using technology in the field provided two opportunities to identify personal attributes; i) critical thinking; and ii) offering new ways of thinking (Table 5.9).

Of the eight students who were unsure or did not think that technology in fieldwork could be used to enhance their fieldwork knowledge and skills, one student commented that technology was not an essential part of fieldwork (Table 5.10), and that technology often replicated what could already be done, without adding anything additional fieldwork knowledge and skills opportunities (Table 5.10).

Table 5.10 Student quotes to illustrate thoughts on whether technology can be used to enhance their fieldwork knowledge and skills.

Theme	Student quote
Not essential.	*"While technology is useful it may not work well for everyone, and you can conduct fieldwork without it." S66*
Does not add anything.	*"If the table is the same as it is on paper and you are good at taking copies of the paper records and collaborating, then I am not sure how much of a difference it makes." S142*

During the pre-fieldwork survey, students reflected upon seven fieldwork skills and self-reported their competency of these skills using a 4-point Likert scale (*'1. Not at all skilled, '2. Not very skilled', '3. Somewhat skilled', '4. Skilled'* (Figure 5.8). These seven fieldwork skills were identified by a review of the module outline form for each fieldwork element that the students were undertaking and from the authors own experience of the fieldwork undertaken by the students.

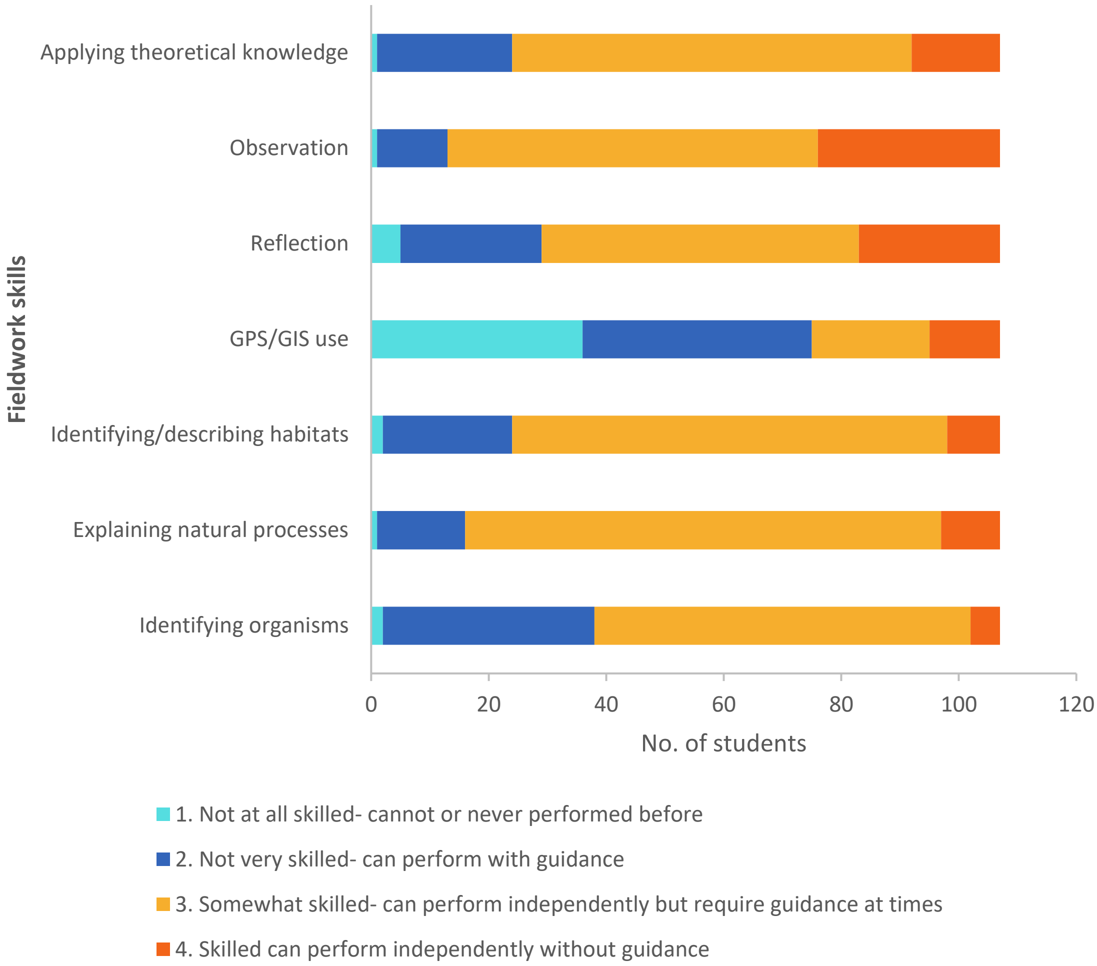

Figure 5.8 Student self-reported competency of seven fieldwork skills recorded using a 4-point Likert scale.

In grouping each of these seven skills into 'Knowledge-based' (Applying theoretical knowledge, GPS/GIS use, Identifying/describing habitats, Explaining natural processes, Identifying organisms) or 'Transferable' (Observation, Reflection) a Schreier-Ray-Hare test showed that the interaction between these two factors did not have a significant affect, though student response was affected by overall skill type (χ^2 Skill Type = 12.83, $P < 0.001$) and affected by individual fieldwork skills (χ^2 Fieldwork skills = 79.65, $P < 0.001$).

Observation was the fieldwork skill area that had the highest number of students (93 students, 86.9% of all students) who reported that they were, '*3. Somewhat skilled*' or '*4. Skilled'*. Explaining natural processes was the fieldwork skill area that had the second highest number of students (91 students, 85.0% of all students) who reported that they were, '*3. Somewhat skilled*' or '*4. Skilled'*. GPS/GIS was the fieldwork skill area that had the highest number of students (75 students, 70.1% of all students) who reported that they were, *'1. Not at all skilled'* or *'2. Not very skilled'*. Identifying organisms was the skill area that had the second highest number of students (38 students, 35.5% of all students) who reported that they were, *'1. Not at all skilled'* or *'2. Not very skilled'.*

In reviewing DFN entries where both photo (Figure 5.9) and species name were submitted (n = 22), it is possible to determine if students' identification were correct. Of these, 15 photos were correctly identified to species level. The five entries where students had identified to a class level e.g., Brittle star (Ophiuroidea) or genus level e.g. Longhorn moth (*Nemophora*) without knowing exact species.

Figure 5.9 Photos inputted to the Digital Field Notebook (DFN). Key identifies which species had correct identification, which had partial species identification e.g., correct genus or family, and those species which were unknown (n = 22).

We can compare this reviewed species identification within the DFN (Figure 5.9) with students' self-reported competency in species identification in the pre-fieldwork survey and self-reported confidence of species identification when submitting the DFN entry. Although each measure used a different 'Likert' scale of response (Table 5.11), it was possible to review the scales and combine responses (Table 5.12). A higher percentage of students were *'Not skilled'* in species identification in the pre-fieldwork survey (38 out of 107, 35.5% of responses) when compared to self-reported confidence in the DFN entry (7 out of 33, 21.2% of DFN entries), and in the review of species identified in the DFN entry (2 out of 22, 9.1% of DFN entries: Figure 5.10). A minority of students self-reported competency of species identification responses in the pre-fieldwork was *'Skilled'* (5 out of 107, 4.7% of responses), while these made up the majority of entries in the self-reported confidence of species identification within the DFN entries (24 out of 33, 72.7% of DFN entries), and with the majority of species being correctly identified within the DFN entry (15 out of 22, 68.1% of DFN entries). This is perhaps showing a tendency for students with higher species identification skill level to use the DFN, and/or students were only inputting entries into the DFN when they were confident that the species identification was correct.

Table 5.11 Comparing the different measures of species identification competency and confidence from the pre-fieldwork surveys and Digital Field Notebook (DFN) entries.

Self-reported competency of species identification (pre-fieldwork survey) (n = 107)		**Self-reported confidence when submitting species (DFN entry) (n = 33)**		**Review of species identified (DFN entry) (n = 22)**	
Likert statement	**Frequency**	**Likert statement**	**Frequency**	**Identification**	**Frequency**
'1. Not at all skilled'.	2	*'1. Not very confident'.*	3	Incorrect identification.	2
'2. Not very skilled'.	36	*'2. Slightly confident'.*	4	Partial identification.	5
'3. Somewhat skilled'.	64	*'3. Somewhat confident'.*	2	Correct identification.	15
'4. Skilled'.	5	*'4. Fairly confident'.*	8		
		'5. Extremely confident'.	16		

Table 5.12 Comparing the different measures of species identification competency and confidence from the pre-fieldwork surveys and Digital Field Notebook (DFN) entries on a combined Likert scale ('1. Not/not very skilled', '2. Somewhat skilled', '3. Skilled').

Likert statement	**Self-reported competency of species identification (pre-fieldwork survey) (n = 107)**	**Self-reported confidence when submitting species (DFN entry) (n = 33)**	**Review of species identified (DFN entry) (n = 22)**
'Not/not very skilled'.	38	7	2
'Somewhat skilled'.	64	2	5
'Skilled'.	5	24	15

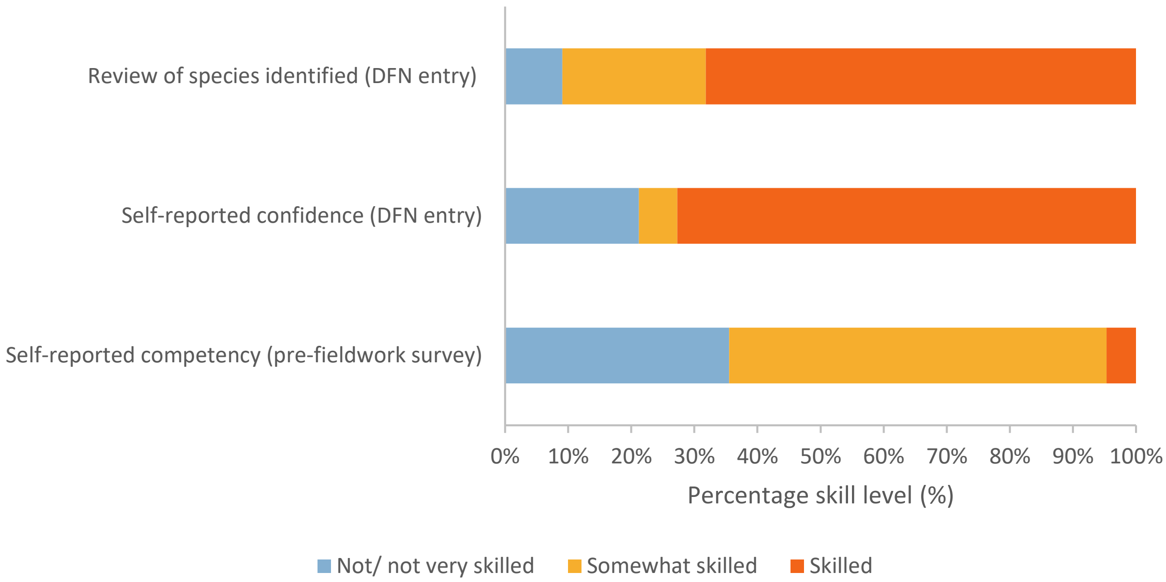

Figure 5.10 Comparing percentage species identification skill level from the self-reported competency (pre-fieldwork survey n = 107), self-reported confidence (DFN entry n = 33) and review of species identified (DFN entry n = 22).

When submitting an entry into the DFN, students were asked to define the habitat using the Phase 1 classification system (Figure 5.11). Forty-four percent (16 out of 36) of the entries classified the habitat as coastal and 31% (11 out of 16) of the entries classified the habitat as woodland and scrub, meaning that 75% of DFN entries correctly identified the habitat that they were working in using the Phase 1 classification system.

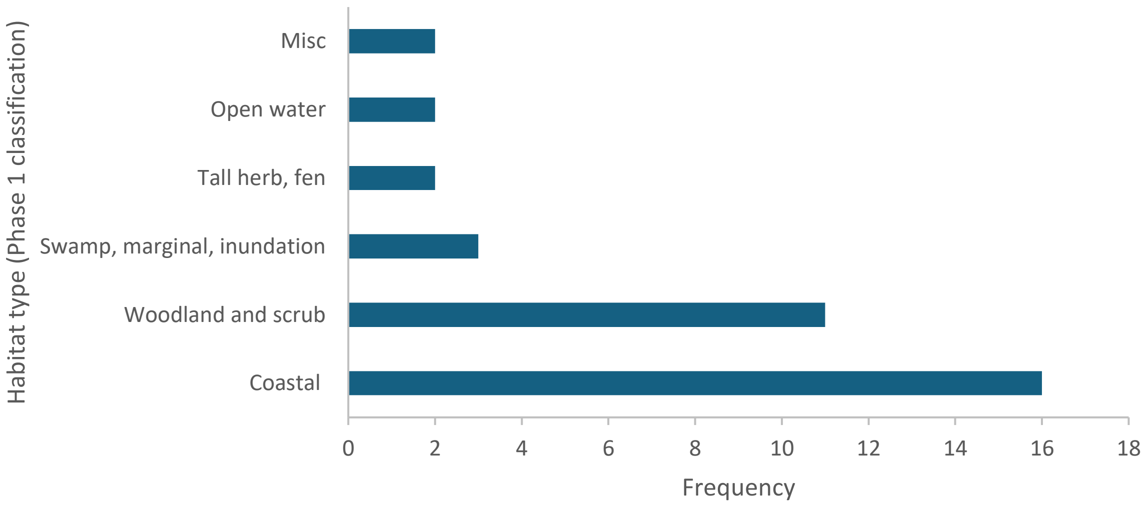

Figure 5.11 Habitat description (Phase 1 classification) of the Digital Field Notebook (DFN) entry (n = 36).

In reviewing students' DFN entries to the prompt*, 'Description- Share any unique information about this organism, its behaviour or the habitat it is in'* it offers the chance to evidence some of the fieldwork skills that students self-reported their competency in during the pre-fieldwork survey. Deductive content analysis was performed on these student responses using categories which represent form and function of organisms which could be helpful to classify organisms (behaviour, morphology, and distribution in environment) (Table 5.13; 5.14).

Table 5.13 Summary of the content analysis of each of the Digital Field Notebook (DFN) entries to the prompt; 'Description- Share any unique information about this organism, its behaviour or the habitat it is in'. Deductive content analysis was conducted using three categories representing an assessment rubric (behaviour, morphology, distribution in environment) as a measure to classify the form and function of organisms (n = 22). Grey shading denotes that the DFN entry contained information on that element of the assessment rubric.

	DFN Entry	Behaviour	Morphology	Distribution in environment
	1			
	2			
	3			
	4			
	5			
	6			
	8			
	11			
	12			
	13			
	14			
	15			
	19			
	23			
	24			
	25			
	28			
	30			
	36			
	37			
	38			
	39			
Total	**22**	**4**	**15**	**8**

Table 5.14 Examples of students' Digital Field Notebook (DFN) entries to illustrate the categories of the assessment rubric (behaviour, morphology, distribution in environment).

Category of rubric	DFN entry
Description of morphology.	*"Airtight seal on rock on intertidal area." DFN 14*
	"Large hedgerow plant with golden brown leaves." DFN 37
	"Three-pointed tail." DFN 38
Description of an organisms' distribution in the environment.	*"Each tree is fairly spaced apart." DFN 30*
	"On the surface of the shore, low shore." DFN 13
Description on the behaviour, morphology of an organism and its distribution in the environment.	*"Was blob like out of the water until when in water and then it's tentacles came out." DFN 23*

Sixty-eight percent (15 out of 22) of entries included a description of the morphology of organisms (Table 5.14). Thirty-six percent (8 out of 22) of entries included a description of an organisms' distribution in the environment (Table 5.14). There was only one entry that included a description on the behaviour, morphology of an organism and its distribution in the environment (Table 5.14). Two entries (DFN Entry No. 19 and 39) did not include information that could be coded into any of these three categories.

In reviewing students' DFN entries to the prompt; *'Describe any patterns or features you can observe in the environment'* it offered the chance to evidence some of the fieldwork skills that students self-reported their competency in during the pre-fieldwork survey. Deductive content analysis was performed on these student responses using assessment rubric categories which represent an increasing quality of observations made about the environment (list of features present, detailed description, specialised vocabulary, interpretation offered). Table 5.15 and Figure 5.12 summarises the content analysis of each of the DFN entries, with Table 5.16 providing examples of student DFN entries.

Table 5.15 Summary of the content analysis of each of the Digital Field Notebook (DFN) entries to the prompt; 'Describe any patterns or features you can observe in the environment'. Deductive content analysis was conducted using four categories (list features present, detailed description, use of specialised vocabulary, interpretation offered) as a measure of increasing quality of the observations (n = 27). Grey shading denotes that the DFN entry contained information on that category.

Increasing quality of the environment observations

	DFN Entry	List features present	Detailed description	Specialised vocabulary	Interpretation offered
	1		■	■	
	2		■	■	■
	3		■	■	■
	4		■	■	■
	5		■		
	6		■	■	
	7	■			
	8	■			
	9		■	■	
	10		■		
	11		■		
	12		■		■
	13		■		
	14	■			
	15			■	
	18	■			
	22	■			
	23	■			
	24	■			
	25		■		
	26	■			
	27		■	■	
	28		■	■	
	29		■	■	
	30		■	■	■
	36		■		
	39	■			
Total	**27**	**11**	**17**	**11**	**5**

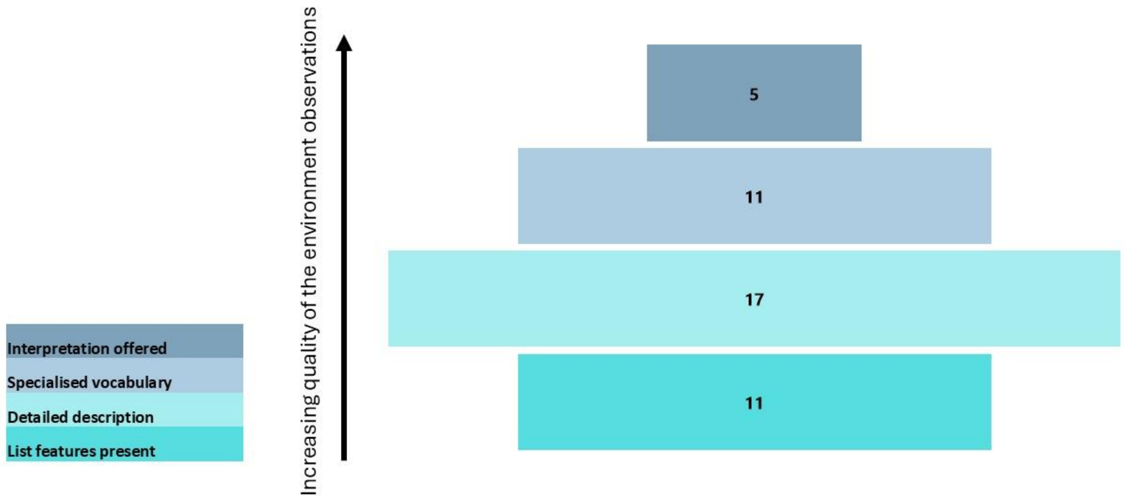

Figure 5.12 Summary of the deductive content analysis of each of the Digital Field Notebook (DFN) entries (n = 27) to the prompt; 'Describe any patterns or features you can observe in the environment'. Deductive content analysis was conducted using four categories (list features present, detailed description, use of specialised vocabulary, interpretation offered) as a measure of increasing quality of the observations.

Table 5.16 Examples of students' Digital Field Notebook (DFN) entries to illustrate the categories of the assessment rubric (list features present, detailed description, specialised vocabulary, interpretation offered).

Category of rubric	**DFN entry**
List features present.	*"Loads of barnacles and limpets and rock pools." DFN 24*
	"Lots of deadwood and holly shrubs." DFN 26
	"River, rocks, trees, beach." DFN 39
Detailed description.	*"Worm was buried into sediment with a few small moveable rocks above, the water was quite shallow and there wasn't much seaweed present." DFN 25*
	"Sediment gets more coarse on the northern end of the beach." DFN 10
Specialised vocabulary.	*"Dominated by brown bent and tussock sedge and very wet waterlogged soil." DFN 6*
	"Zonation of sediment about 0.5 mm at top and gradually changing to cobbles then boulders." DFN 9
	"Limited vegetation on ground. High volume of dead wood. Limited invertebrate life except decomposers." DFN 27
Interpretation offered.	*"Large variation of grain size due to sorting." DFN 12*
	"Flush bankside, tree cover becomes more dense towards mixed woodland but most flora on bank is exposed to light. Highly diverse. Terrain is sedimentary as a result of the high tide, and trash lines are present after recent flooding." DFN 4

There were 11 instances when the responses included a simple list of features present (Table 5.16) and 17 instances where student responses offered a detailed description of the environment (Table 5.16). Specialised vocabulary was identified in 11 of the DFN entries (Table 5.16). There were five occasions where students offered interpretation in their observations of the environment.

One of the prompts within the DFN asked students to *'Consider what physical processes and human impacts are having the biggest impact in this environment'* and to *'explain why'.* Figure 5.13 summarises the physical processes and human impacts identified by students. Students identified 13 human impacts which were impacting the fieldwork environments they were working in and five physical processes. Of the 28 responses; 16 offered explanation and specific detail on the consequences of these processes and/or impacts, examples of these DFN entries are shown in Table 5.17.

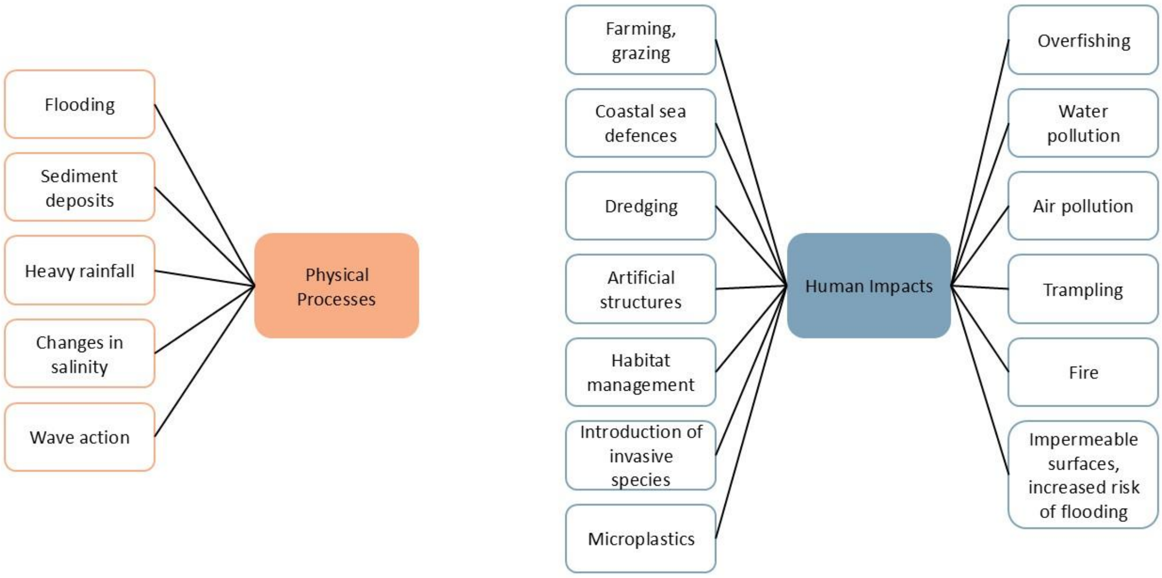

Figure 5.13 Summary of the themes identified from the reflexive thematic analysis of the student responses to the question; 'Consider what physical processes and human impacts are having the biggest impact in this environment. Why?' (n = 28).

Table 5.17 Digital Field Notebook (DFN) entries which offered explanation and specific detail on the consequences of the identified physical processes and/or human impacts.

	DFN entry
Explanation and specific detail on the consequences of these physical processes or human impacts.	*"The tree rot could've been caused by herbivorous insects and lack of nutrients." DFN 30*
	"Invasive species are present which may reduce species diversity/richness of native species." DFN 4
	"Tyres in the sea planted by fishermen to attract crabs. Dredging the channel to remove sediment buildup." DFN 16
	"Human impacts are leading to more floods which washes in seeds of non-native species causing an increase in invasive species." DFN 1
	"This estuary has high industrial and chemical activities use." DFN 15

5.4.3 Supporting students' connection to nature

Within the pre-fieldwork survey students were asked to reflect on what the term 'Nature Connectedness' meant to them. Student responses are summarised in Figure 5.14, six overarching themes were identified in the data during the reflexive thematic analysis. Deductive content analysis was then undertaken on the data using the identified 6 summary themes. Table 5.18 summarises the results of the deductive content analysis and uses student quotes to illustrate these six summary themes.

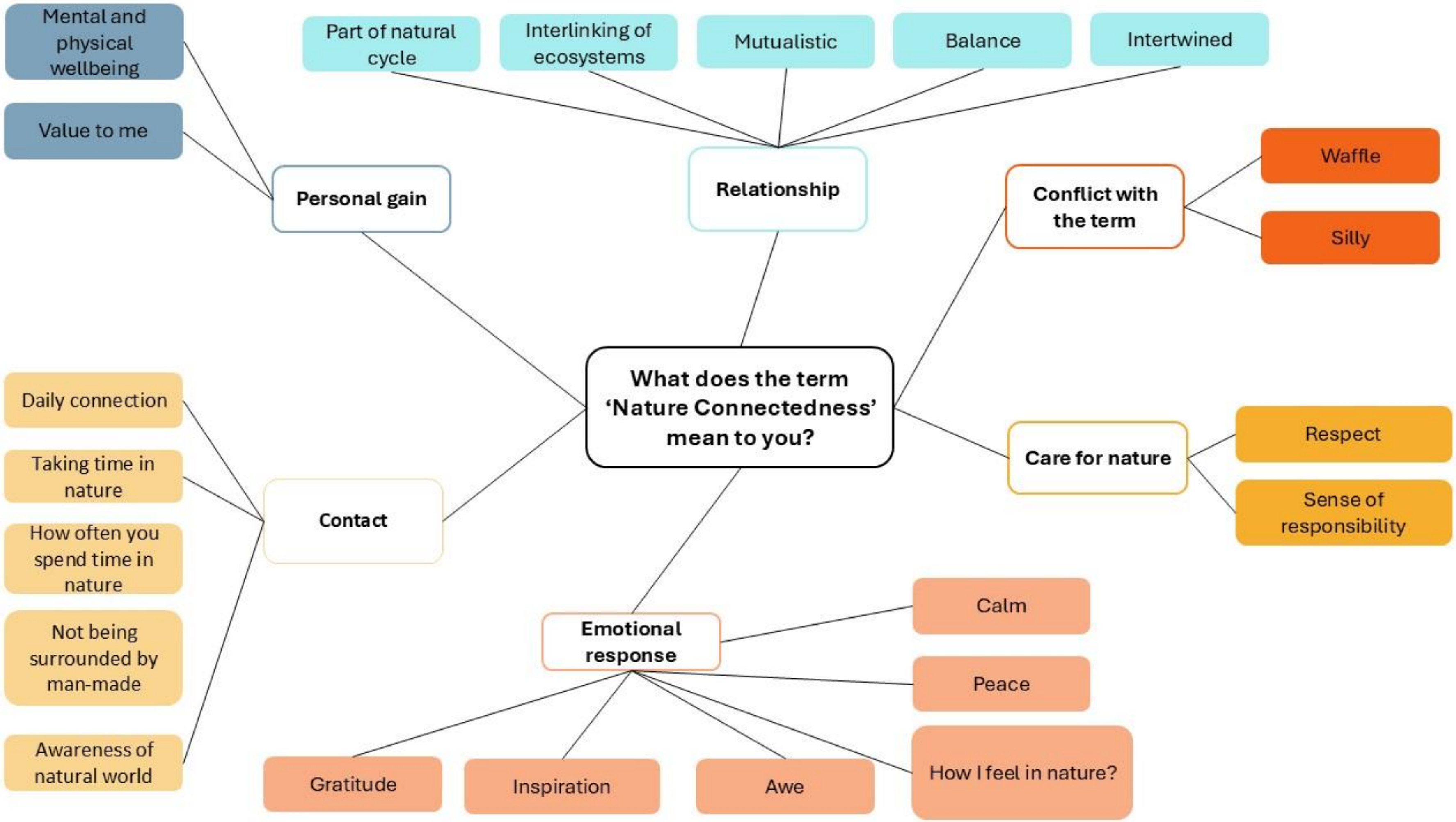

Figure 5.14 Summary of student responses to the question; 'What does the term 'Nature Connectedness' mean to you?' in the pre-fieldwork survey. From the reflexive thematic analysis six main themes were summarised from the data (n = 107).

Table 5.18 Summary of the deductive content analysis undertaken on student responses to the question; 'What does the term 'Nature Connectedness' mean to you?' using the six identified summary themes from the reflexive thematic analysis. Student quotes are provided to illustrate these themes.

Theme	Frequency	Student quote
Emotional response.	**14**	*"If you are appreciative of the natural world around you. Taking time to care for it and have gratitude for it. Not exploiting it or feeling like we can destroy it." S140*
		"How someone feels towards nature and what it means to them." S68
		"Feeling at peace with nature." S71
Contact.	**21**	*"How often you spend time in nature." S114*
		"How much time you take to be in nature." S146
		"How often I feel like I am part of nature and not surrounded by anything man made." S63
Relationship.	**63**	*"Being at one with the world around you and understanding that everything and everyone is connected in some way, shape or form." S58*
		"Feeling intertwined and involved physically and spiritually in nature." S67
		"Feeling at peace with nature, that we are but one organism in a huge biome and we are one with the environment." S71
Care for nature.	**14**	*"Being able to understand how your actions affect nature." S66*
		"Knowing that the actions I have can have implications within the natural world." S82

		"Feeling a responsibility as a more intelligent being to protect preserve and promote nature." S99
Personal gain.	**8**	*"My mental and physical wellbeing is interconnected with the natural environment." S56*
		"Positive effects on my soul." S74
Conflict with the term.	**2**	*"A silly term there's no need to label everything but I guess an understanding of all the biological worlds interactions." S125*

One of these themes 'Emotional response' summarised students' emotional literacy and personal feelings that students associated with nature connectedness. These included calm, peace, awe, inspiration, gratitude (Table 5.18). Some students identified that nature connectedness was linked to contact with nature (Table 5.18). Another theme identified related to nature connectedness was a relationship with nature, with students defining that specific relationship (Table 5.18). Care for nature was identified as a theme related to nature connectedness, with students sharing their role in supporting nature (Table 5.18). Nature connectedness was a term that students associated with personal gain, and the associated mental and physical wellbeing benefits, and personal value (Table 5.18). Some students however, demonstrated a conflict with the term (Table 5.18). Many of the definitions were comprehensive and incorporated multiple themes (Table 5.19)

Table 5.19 Student quotes to illustrate comprehensive responses to the question; 'What does the term' Nature Connectedness' mean to you?' in the pre-fieldwork survey.

Student quotes
"Spiritual alignment with the non-human natural world, and a conscientious outlook regarding the way one operates within it." S109
"Being aware of the impact humans have to remove nature from public spaces. Being connected by nature every day instead of concrete. Understand the impact people have on natural systems through (mainly) hyper consumption removing natural materials - especially animal agriculture :(." S136

"For me, this means reconnecting with what I believe are the most important, primal aspects of our existence. The world we live in today is moving further and further from nature with the growth of technology, social media and self-comparison with the rich and famous. Nature connectedness is about disregarding these man-made things which offer superficial happiness and instead getting back in touch with the Earth itself, be it through meditation, long walks, nature swims or gardening. We forget to appreciate our own habitat far too often!" S86

A PCA was undertaken on the results of the deductive content analysis of the student responses to ''What does the term 'Nature Connectedness' mean to you?' to determine which of the themes in Table 5.18 could be attributed to the driving forces of degree choice, ('Biology', 'Zoology', 'Marine Biology', 'Marine Zoology'), or whether other factors were important in driving students understanding of the term nature connectedness. The PCA revealed the presence of three components with Eigen values exceeding 1, which accounted for 100% of the total variance (Table 5.20). The PCA plot (Figure 5.15) shows that degree choice did drive student themes related to the definition of nature connectedness. The themes 'Relationship', 'Emotional response' and 'Personal gain' were themes associated with the degree of marine biology. This could be explained by undergraduate teaching on this degree programme, with research by academic staff within marine biology who specialised in interdisciplinary research on 'Society, Management and Governance' including work with coastal communities and wellbeing dimensions related to the marine environment. In contrast the theme of 'Contact' for the definition Nature Connectedness was a factor driven by the degree choice of biology. This could be explained by the undergraduate traditional teaching focus on species recognition and biodiversity records on this degree programme.

Table 5.20 Principal Component Analysis (PCA) values identifying three principal components to the themes from the student responses to the questions 'What does the term 'Nature Connectedness' mean to you?' and degree choice.

Principle component	**Eigenvalue**	**% Variation**	**Cumulative % Variation**
1.	4.6	76.7	76.7
2.	0.985	16.4	93.1
3.	0.411	6.9	100

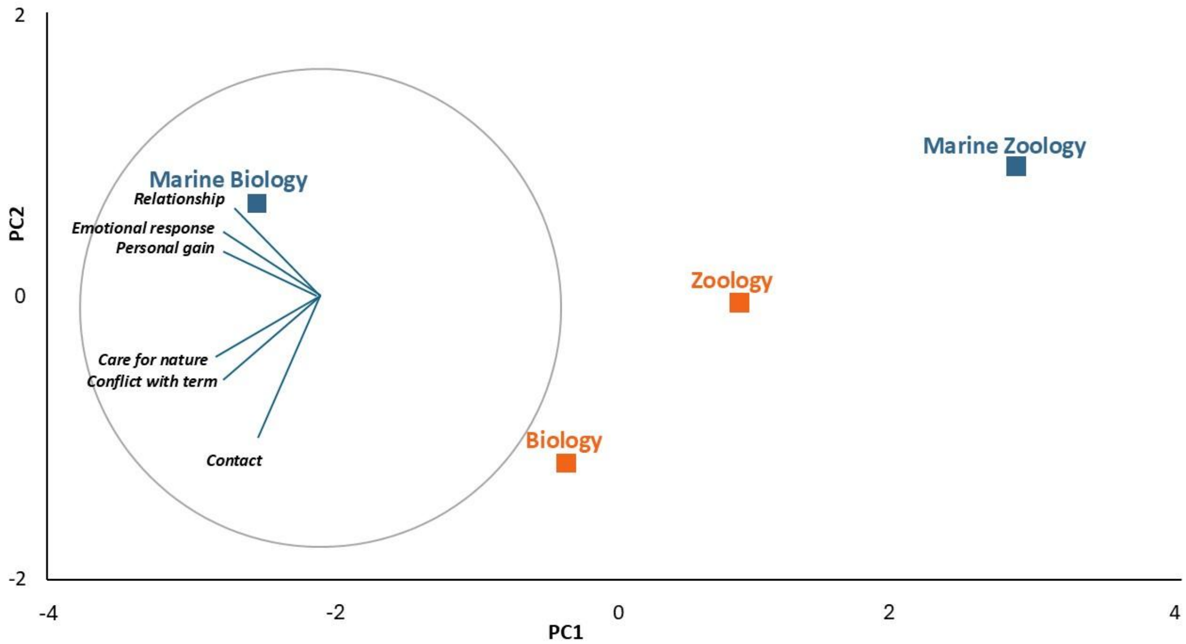

Figure 5.15 Principal Component Analysis (PCA) plot to show which of the themes from student responses to the question 'What does the term 'Nature Connectedness' mean to you?' can be attributed to degree choice.

Beyond students' understanding of the term, a measure of students' nature connectedness was assessed in the pre-fieldwork survey. Students CNS scores were calculated from the 14-item assessment with the distribution of CNS scores plotted in Figure 5.16.

The median CNS score for first year undergraduates was 51 and 52.5 for second year undergraduates. Despite the range of CNS scores being 34 for first year undergraduates and 29 for second year undergraduates, the interquartile range for both data sets showcase a tight clustering around the mean. Yet despite this, there was a large range in students' CNS scores, with some students' scores very low, showing a low nature connectedness. The CNS scores of first year undergraduates and second year undergraduates were analysed using the Mann Whitney-*U* statistical test which showed that the difference was not statistically significant (U = 1298.5, P = 0.412). The low nature connectedness scores cannot be explained by the compulsory (first year undergraduate) or optional (second year undergraduate) nature of the fieldwork.

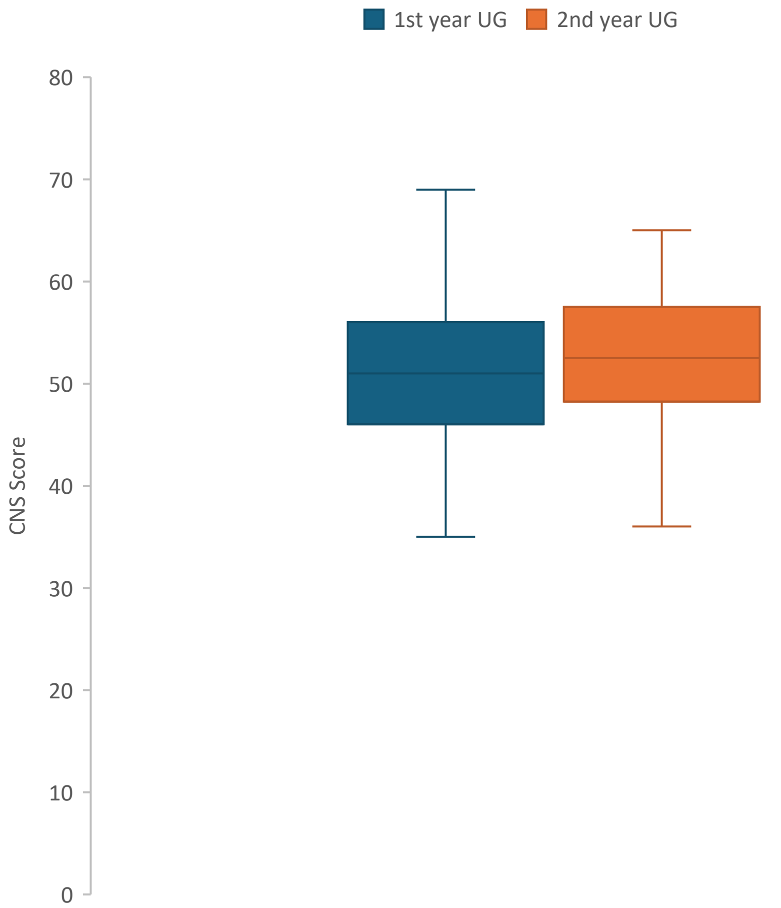

Figure 5.16 Median (± range) Connectedness to Nature Scores (CNS) (Mayer and Frantz, 2004) of first year (n = 55) and second year undergraduates (n = 52).

Informed by the work of Richardson *et al.* (2015), when using the DFN one aspect of the Nature Connectedness questions asked students to identify three good things in nature. Student responses are summarised in Figure 5.17, higher frequency items are displayed larger in the word cloud, with colours used to categorise the responses. Table 5.21 provides information on the frequency of items in these categories. Features in the physical landscape were almost four times more likely to be identified than individual marine organisms or birds. It is interesting to see that the themes 'Adjectives, verbs' and 'Landscape features' are the two highest frequency themes within student responses (Table 5.21), yet are not prominent in Figure 5.17, suggesting a higher diversity in the terms used. This perhaps shows that students use a range of vocabulary to describe features in the landscape.

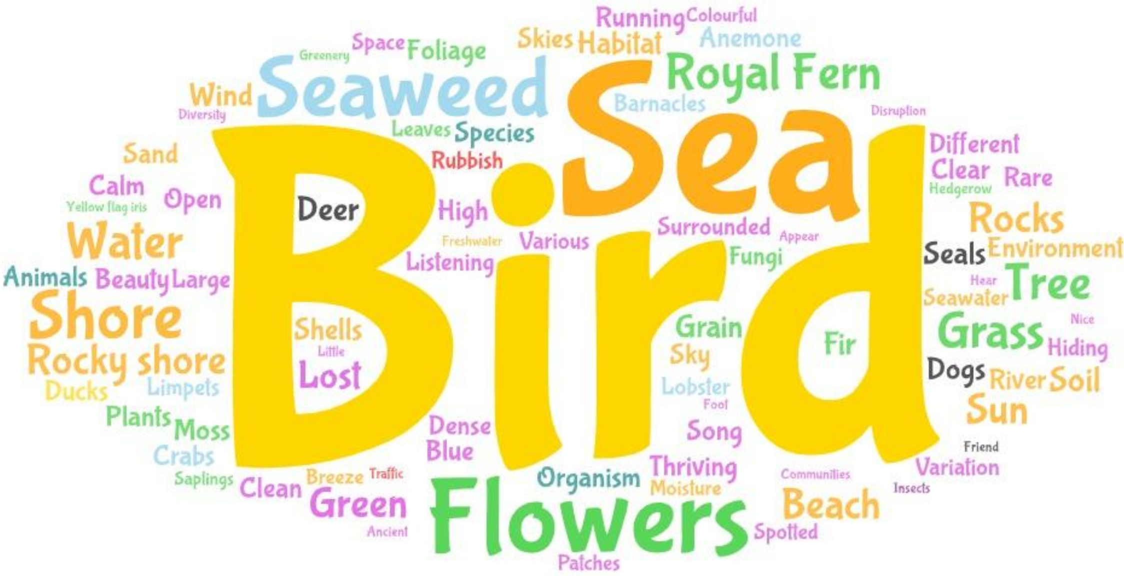

Figure 5.17 Students' responses to the Digital Field Notebook (DFN) prompt 'Three good things in nature' (Richardson et al., 2015). Higher frequency items are displayed larger in the word cloud. Colours categorise the theme of these items. (Yellow = birds; Orange = landscape features; Green = vegetation; Blue = marine organisms; Purple = adjectives/verbs used to describe or denote action; Black = mammals; Red = man-made; Purple = insects).

Table 5.21 Frequency of the content analysis within student responses to the Digital Field Notebook (DFN) prompt; 'Three good things in nature' (Richardson et al., 2015).

Theme	Adjectives, verbs	Landscape features	Vegetation	Marine organisms	Birds	Mammals	Man-made	Insects
Frequency	**45**	**44**	**27**	**12**	**11**	**4**	**2**	**1**

Students were asked to classify how the three good things in nature made them feel, using a classification of mood based on energy and pleasantness (Brackett *et al*., 2024) (Figure 5.18).

There were no 'high energy, unpleasant' (red) moods identified by students when in nature. Most of the moods experienced were either 'low energy, pleasant' (green) moods or 'high energy, pleasant' (yellow) moods both with 48% of total moods shared.

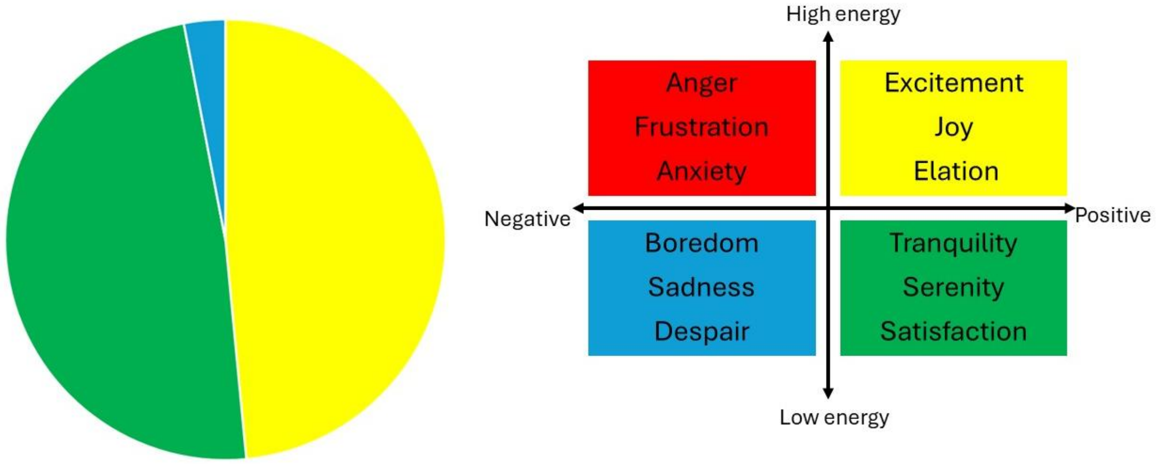

Figure 5.18 Student classification of their mood based on the Digital Field Notebook (DFN) prompt; 'How did these three good things in nature make you feel?' (n = 33).

Students were asked to share something that brought them joy and wonder at the location of their DFN entry. Students' responses are grouped into themes which were identified inductively, with a content analysis conducted to determine frequency of each of these themes (Table 5.22). Table 5.23 uses example student responses to illustrate some of these themes.

Table 5.22 Frequency of students' responses to the Digital Field Notebook (DFN) prompt; 'Share something that has brought you joy and wonder at this location?' summarised into themes.

Theme	**Frequency**
Finding, spotting animals.	11
Physical environment.	8
Sounds in nature.	5
Learning.	3
Humans.	3
Absence of man-made items.	1
Total	31

Table 5.23 Student quotes to illustrate the themes identified from students' responses to the Digital Field Notebook (DFN) prompt; 'Share something that has brought you joy and wonder at this location?'

Theme	Student quote
Findings, spotting animals.	*"Wildlife such as voles and rabbits nearby." DFN 2*
	"Catching a lobster!" DFN 18
	"Deer fawn spotting." DFN 26
	"Possibility of seeing animals." DFN 31
	"Otter paw prints." DFN 39
Physical environment.	*"The sea and the calm wave action." DFN 10*
	"Spending time in the fresh air." DFN 12
	"Diversity of habitats and communities." DFN 5
Sounds in nature.	*"Birds singing in trees." DFN 36*
	"The sound of running water." DFN 37
	"You can hear the animals all around and not many vehicles or loud noises, very calm." DFN 1
Learning.	*"Being able to study nature with people that have similar interests to me."*
	"Teamwork and successfully identifying the plants and habitat present whilst furthering my knowledge." DFN 5
	"Fully identifying the plants and habitat present whilst furthering my knowledge." DFN 6

Thirty-five percent (11 out of 31) of the things that brought joy and wonder related to finding and spotting animals during fieldwork, often reflecting upon the more 'exotic' animals. This also included the potential of seeing animals, or traces of animals (Table 5.23). Twenty-six percent (8 out of 31) of the things that brought joy and wonder related to items in the physical environment (Table 5.23). Sounds in nature (16% 5 out of 31) and the absence of man-made noises was something that brought students joy and wonder (Table

5.23). Learning that occurred during the fieldwork accounted for 10% (3 out of 31) of responses with students identifying that learning new things with their peers was something that brought them joy and wonder (Table 5.23).

5.5 Discussion

5.5.1 Low uptake of DFN use during bioscience fieldwork

Features of the DFN met the needs of what students identified should be recorded during fieldwork within this research. The only aspects deemed important by students that the DFN did not record was information on weather and the quantitative data, which would be specific to individual fieldwork enquiries and contexts. In not including the ability to collect these specific data and focusing on more qualitative observations, it is anticipated that the DFN is transferable to almost all occasions of bioscience fieldwork in HE.

Students overwhelmingly identified value in using technology in fieldwork. These included sharing of information, efficiencies, professional working practice, advancing fieldwork observations and deepening understanding of the fieldwork location. Many of these identified values within this research can also be identified by learners (France *et al*., 2016) and fieldwork facilitators (Welsh *et al*., 2013) in other studies.

However, despite the utility of the DFN, students' perception of technology being positive and the presumed saturation of mobile devices within this population (Pearson, 2015), uptake for using the app during fieldwork within this research was extremely low with overall engagement evidenced by total number of DFN entries (n = 43) and response rate for each section of the DFN (Species identification 69%, Landscape interpretation 64% and Nature connection 65%). Ninety- four percent of students surveyed saw value in the use of technology during fieldwork and all students who had access to the DFN were provided with a compatible tablet device at the start of their studies. Therefore, two of the main fieldwork facilitator perspectives for barriers to the use of technology in fieldwork, 'physical barrier of cost' and, 'human perception of the technology', (Welsh *et al*., 2013) do not appear to be able to explain the low uptake for using the DFN within this research and we must look elsewhere to consider the barriers to using the DFN during fieldwork.

One of the key functions that students identified was important to record was 'data', which students noted referred to the quantitative data relevant to the fieldwork enquiry. Unlike other DFN studies where the tool was tied in directly into the fieldwork task being undertaken (Xie *et al*., 2021; Phantuwongraj *et al*., 2021), this DFN did not enable these data to be collected, as its focus was on broader species identification and landscape interpretation skills. Time management is one of the identified field-ecology challenges (Leon-Beck and Dodick, 2012) and perhaps the low-usage of the DFN suggests a conflict between what students identify as core or the essential fieldwork task and what is additional or optional data collection with these tight fieldwork timescales limiting the optional DFN use.

There were three questions within the DFN that had lower response rates- *'upload photo'*, *'unique information about the species identified'* and *'share something that has brought you wonder and joy'*. While studies have shown that learners engage with geotagging of photos using mobile devices and apps (Latham and McCormack, 2007; Welsh *et al*., 2012) these have all been with geography learners and despite the direct relevance to fieldwork in the biosciences recognised (Welsh *et al.,* 2012) and the importance of spatial biological records (Herbeling and Isaac, 2018; Callaghan *et al*., 2022; López-Guillén *et al*., 2024) this research suggests that bioscience fieldwork students were less willing to submit photos and species records to the DFN.

Additionally, students in this research were less engaged with the more long-form reflective, nature connectedness questions. A difference in response rate for reflective journaling in fieldwork has been identified between paper field notebooks (65% response rate) and in a digital version (15%) (Race *et al*., 2021), with less depth to the journal reflections also identified in the digital version (Race *et al*., 2021). Despite the collaborative nature of fieldwork, which develops teamwork and collaboration skills (Peasland *et al*., 2019) and the identified role that technology can play in supporting that communication (Welsh *et al*., 2013) perhaps students recognised the personal nature of notetaking in the field (Greene, 2011), and therefore had a hesitancy to share in-depth personal reflections via a DFN that collated responses together. Another possible explanation could be the students' lack of understanding on the processes involved and the placement of limited value on the importance of reflection. Although it is identified as a valuable academic skill within the university (Academic Skills Kit Newcastle University, 2024), developing the skills of reflective practice takes time and support within the biosciences (Parry *et al*., 2012) and these students may have limited previous experience of this.

While there is literature on the impact of DFNs and mobile apps in geoscience fieldwork where it improved learners' fieldwork practice (Xie *et al*., 2021) and enhanced the learning experience (Phantuwongraj *et al*., 2021), app use during fieldwork and research remains low (Hinze *et al*., 2023). In summary, students identified potential benefits of a DFN, yet in practice these benefits did not overcome barriers that students faced in using them in the field. It will be useful for future research to consider how better to integrate the DFN within biosciences fieldwork, and to work with learners to better understand and overcome barriers to its use.

5.5.2 Sharing rather than learning with species identification DFN entries

Students identified that the DFN could be used to develop skills, with half of skills identified transferable. This is comparable with another study who identified that transferable skills were more frequently reported by learners during student-led fieldwork (Peasland *et al*., 2019) and reflects the student-led nature of engaging with the DFN and associated question prompts in the field.

In evaluating the student-identified skills that the DFN could help develop in this research, alongside the general fieldwork skills fostered during bioscience residential field courses at a single higher education institution (Peasland *et al*., 2019) and those examined in a broader scoping review of undergraduate field courses in the natural sciences (Shinbrot *et al*., 2022), a significant overlap emerges. Many of the skills gained through the DFN, such as collaboration, critical thinking, and species identification, align with those developed in general field courses without the use of a DFN. However, the DFN also presents distinct opportunities for skill development not highlighted in general fieldwork (Peasland *et al*., 2019; Shinbrot *et al*., 2022), including GIS proficiency, fieldwork note-taking, and data management.

Pre-fieldwork, students recorded that 'GPS/GIS' and 'Species Identification' had the lowest self-reported skill level; yet students self-reported identification skills and confirmed identification within the DFN entries were high. This suggests that students were inputting species into the DFN only when they were confident with the identification of that species or it was the students who had higher species identification skills who were using the DFN. Students were potentially viewing the DFN solely as a tool to share confirmed species identification rather than as a learning tool to develop skills of identification by seeking feedback from peers and facilitators of fieldwork.

While remote online tools for species identification have been found to be effective (Daume and Galaz, 2016; Perry *et al*., 2021), the quality of photographs influences accuracy of identification (Daume and Galaz, 2016; Katrak-Adeforowa *et al*., 2020) and users of these collaborative social-media space for identification were predominantly identified as 'incidental biologists' with no discernible background in biology or 'general nature enthusiasts. This suggests that students do not value this form of community to support species identification, relying on the more traditional identification using dichotomous keys (Scahrf, 2009) to develop their species identification skills.

While learners benefitted from the real-time engagement with collated spatial data sets in other studies (Phantuwongraj *et al*., 2021; Park, 2021), it appeared that students in this study were more concerned with sharing their knowledge, rather than accessing others to enhance their own learning. Inspired by the work of Xie *et al*. (2021), a missed opportunity was for the facilitator to actively engage students with the DFN as a platform for peer-peer and peer-facilitator communication. This affordance was implicit, yet more explicit encouragement may enable enhanced engagement in the future.

5.5.3 Species literacy

Alongside identifying species, students were asked to share details about the species within the DFN. Most entries described species morphology (68%), yet only 36% included information on an organism's distribution in the environment and even fewer still discussed an organism's behaviour (18%). While the lower number of descriptions that contained information on behaviour can be explained by a proportion of the DFN entries focusing on vegetation, the lack of information shared on an organisms' distribution in an environment also shows that broad observation and knowledge of a species beyond its identification was lacking in some of the entries and could illustrate that species literacy was an under-developed skill area of students in this study. Students were able to look at a species in isolation but not in relation to its broader connection to the environment (Hooykaas *et al*., 2019). This has been identified as important to understand an environment fully (Palmberg *et al*., 2015) and can contribute to an individuals' sense of place to a fieldwork location (Horwitz *et al*., 2001; Standish *et al*., 2013).

Pre-fieldwork 'Observation' was the skill that had the highest number of students who reported that they were skilled or somewhat skilled. Yet in the landscape observations shared within the DFN, while the majority of students were able to provide a detailed description, less than half demonstrated the use of specialised vocabulary and even fewer offered any interpretation. This interpretation of an environment is important to develop an individual's connection to a location and develop a sense of place (Drenthen, 2011). Although the reasons for this lack of interpretation in students' observations is unclear, several possibilities could explain it. Students may be unaware that interpretation forms part of the observation process, or hesitant to share an interpretation that may be incorrect within the DFN as entries were collated and shared with their peers. Additionally, these students may not yet have the appropriate level of observation skills to provide an interpretation alongside their observation.

Developing a learner's sense of place within fieldwork can be a strategy to recruit and retain under-represented minorities in ecology (Bowser and Cid, 2021), widen participation in the geosciences (Ward *et al*., 2018) and promote inclusive practice (Morales *et al*., 2020). The DFN provided an opportunity for students to contribute their own sense of place with this collation of authentic voices enabling students to access a diverse collection of students' understanding of sense of place within a fieldwork location, which has been identified as enhancing knowledge and understanding within geography fieldwork (Maddison *et al*., 2023b). A focus on observation in fieldwork builds a sense of community, as learners connect with a landscape and with each other (Jolley *et al*., 2018) with the value of this recognised by learners within this research.

Perhaps a limitation of the DFN that may have restricted the quality of responses are students understanding of what landscape interpretation entails. In an example of a 'photo-essay' task used within landscape interpretation a qualitative rubric is recommended, with drafts submitted for formative assessment, which resulted in more sophisticated learner outputs (Bourque and Hamerlinck, 2021). This may be vital in developing these skills in learners who may be more familiar with a quantitative focussed fieldwork experience.

5.5.4 Connecting to nature during biosciences fieldwork

Overall, the definitions of nature connectedness offered by the students in this research present a strong understanding of nature connectedness that matches the definitions and practice within the literature (Lumber *et al*., 2017; Richardson and Butler, 2022). However, there were definitions shared that discussed conflict with the term, and despite students studying biosciences, there were some students who evidently did not engage with nature connectedness practice, which was also echoed in some of the pre-fieldwork nature connectedness scores.

During fieldwork the majority of moods recorded by students within the DFN were positive (green and yellow mood categories). Fieldwork settings have been identified as threatening environments that promote anxiety for learners (Dillon *et al*., 2006; Boyle *et al*., 2007). Although this does not appear to be case from the DFN entries within this research, we need to reflect upon the low number of DFN entries and the overall low usage of the DFN, which is the biggest limitation of this research, and reduces the reliability and generalisability of this research. This research suggests that the majority of DFN entries were submitted when species identification was known. Are the more confident, experienced fieldworkers the ones who are submitting DFN entries? With those students who lack confidence in fieldwork not using the DFN? Or are students only submitting entries when a species identification is known, with students not seeing value in the DFN as a learning tool to collaborate with peers and facilitators of fieldwork to develop species identification skills. This presents a future research opportunity to consider those that are not using the DFN, and recording their demographics, their self-reported skill levels and observation of their notetaking and participation during fieldwork.

Landscape interpretation is crucial to the formation of a sense of place (Drenthen, 2011). Features in the natural landscape were aspects that students identified were 'good things in nature', this is in line with the specific aspects of nature that were identified (Richardson *et al*., 2015). Functional aspects of the landscape should be recognised, celebrated, valued to support connection with nature (Newman and Dale, 2013). This showcases how interlinked observation and landscape interpretation skills are with developing a sense of place and nature connectedness of an individual. Yet the potential of the DFN as a tool to better connect these factors during fieldwork needs to be better understood. A longitudinal study, although challenging to implement, would enable an understanding of how the DFN captures outcome variables of nature connection, species literacy and observation skills change over individuals' fieldwork occasions throughout the HE experiences.

5.6 Limitations

Limitations of the methods of data analysis (reflexive thematic analysis, content analysis and PCA) are already considered within Chapter 2 (section 2.5). Additionally, the small number of DFN entries limits the representativeness and reliability of findings shared within this chapter. Despite larger number of students completing the pre-fieldwork survey, the uptake of using the DFN in the field (evidenced by the number of DFN entries) remains low. Understanding the barriers to its use remains a priority to ensure effective integration of the tool and more robust findings on the impact of using the DFN to demonstrate the development of fieldwork skills and connection to nature.

5.7 Summary

The DFN presented met the needs of what the first year marine biology/marine zoology and second year biology/zoology students in this research said was important to record in the field. These students recognised the value of using technology in the field, and shared multiple reasons why including efficiencies, advancing observations, and sharing data. However, despite this, DFN usage within these student groups was low during their fieldwork, showing that there are barriers to using the DFN that are not fully understood within this research, and warrant further research to embed the DFN within fieldwork. In evaluating the small number of student entries in the DFN there is a preference for confirmed species identification to be inputted into the DFN or those with higher species identification skills are the students using the DFN. The DFN has a role to play in supporting landscape interpretation, species literacy and nature connectedness within fieldwork in the biosciences. Yet more structured and explicit integration of the tool is needed.

Chapter 6. Participatory Workshops: A method to assess participants' interest in adopting four digital tools in fieldwork education

Abstract

The use of digital tools in fieldwork education is an often-contested issue, with many barriers to their adoption. Although there are numerous studies on the use of digital tools in fieldwork education, they are often case studies of an approach or share facilitator and/or learner perspectives on the tools. While the barriers to adopting digital tools in fieldwork are well understood, there is little research aimed at addressing the barriers that facilitators face in adopting and embedding digital tools in fieldwork. Informed by technology acceptance models and open scholarship practice, this research uses participatory workshops both as a method of disseminating four digital fieldwork approaches (Digital Field Notebooks (DFNs), Virtual Field Trips (VFTs), Digital Preparation Resources and Live Broadcast) to participants and as a method of gathering quantitative and qualitative data on participants' interest in adoption of the approaches and the role of them as a source of inspiration. Digital Action Plans and a post-workshop survey captured the impact of participating in the workshop. Workshop participants identified 38 new ideas and adaptations to the four digital approaches, and overall participants showed an interest in adopting three of the four digital tools (DFNs, VFTs and Digital Preparation Resources). The workshop increased participant self-identified knowledge of specific digital tools, as well as the purpose of the approaches and how to use them.

This research identifies value in using participatory workshops as a method to disseminate education research outputs and enable collaboration amongst practitioners which can help to support the integration of digital tools in fieldwork.

6.1 Introduction

The use and integration of digital technologies in biosciences and geography, earth, and environmental science (GEES) fieldwork is contested. While some see digital approaches as a factor in reducing the outdoor fieldwork opportunities for learners (Boyle *et al*., 2007, Maw *et al*., 2011), others identify value in the complementary approach of using technology embedded within existing fieldwork practice (Thorndycraft *et al*., 2009; Stokes *et al*., 2012; Edwards and Larson, 2020).

6.1.1 Acceptance of technology in fieldwork

There are several frameworks within the literature that aim to support the acceptance and integration of technology. Generalised models of technology acceptance such as The Unified Theory of Acceptance and Use of Technology (UTAUT) (Marikyan and Papagiannidis, 2023; Xue *et al*., 2024) focus on several factors that influence this acceptance (Davis, 1989; Marikyan and Papagiannidis, 2023). Firstly, ease of use, the perception by users, of how easy the technology is to use and adopt, without extensive onboarding or the requirement of specific knowledge and skills. The second factor is suggested to come from social influence, the extent to which users are aware of and respond to others communicating about and using the technology. Finally, its usefulness, the perception of the role that technology can play and what it can bring to the users existing practice (Marikyan and Papagiannidis, 2023). In education, this perceived usefulness is crucial to determining behavioural change which supports technology acceptance (Teo, 2009) and the use of open education resources (OERs) (Kuo *et al*., 2024). To support effective integration of technology in education, the Technology Pedagogical and Content Knowledge (TPACK) framework illustrates the intersecting knowledge that is required (Koehler and Mishra, 2005, Voogt *et al*., 2013). Beyond knowledge, the Digital Technology and Outdoor Experiential Learning (DTOEL) framework (Hills and Thomas, 2020), can be used to support facilitators to have broad discussions about the purposeful use of using digital technologies with learners in the outdoors.

6.1.2 Barriers to adoption of digital tools in fieldwork

While facilitators recognise the role of particular digital tools such as Virtual Field Trips (VFTs) to address some of the teaching and learning challenges in ecology (Cooke *et al*., 2021), the knowledge and skills of staff remain a barrier both to prepare for teaching of fieldwork (Woodley *et al*., 2024) and to adopting digital tools more broadly in fieldwork (Fletcher *et al*., 2007; Welsh *et al*., 2013; Smith and McNeal, 2023). A 'digital divide' is said to exist with the use of digital technologies in education (Afzal *et al*., 2023), and although a digital literacy and skill training program for learners is recommended to empower learners and address this inequality (Afzal *et al*., 2023), there is a need to address these same identified knowledge and capability gaps in educators themselves (Josua and Kanyemba, 2023; Herrera-Pavo and Ornellas, 2024).

In fieldwork this issue could further be exacerbated with facilitators holding potential negative views due to the recent pivot to digital delivery modes of fieldwork during the Covid-19 pandemic (Creech and Shriners, 2020).

6.1.3 Open scholarship

Although there has been an increasing amount of research on technology use in both biosciences and GEES Higher Education (HE) fieldwork, this existing research has focussed on reviewing an individual digital approach in fieldwork (Dolphin *et al*., 2019; Creech and Shriner, 2020; Cowles and Onthank, 2021; Verdes *et al*., 2021), or providing valuable insight into the views and experiences of interested and affected parties (Fletcher *et al*., 2007; Welsh *et al*., 2013; France *et al*., 2016; Clark *et al*., 2020).

Fieldwork facilitators' lack of knowledge, skills and confidence are a barrier to technology adoption in fieldwork (Fletcher *et al*., 2007; Welsh *et al*., 2013), with not all institutions having the required skills or technology to develop their own digital approaches to fieldwork (Guillaume *et al*., 2023). Yet the literature is lacking in its acknowledgement of the potential role of sharing of existing digital tools and a lack of consideration of the effectiveness of a model of training which could enable facilitators to develop knowledge, skills, and confidence in using digital tools in fieldwork.

While open access publishing is seen as a key principle of open research (Cole *et al*., 2023), this only contributes to the broader sharing of research (Greussing *et al*., 2020) and does not necessarily ensure the work is communicated effectively to non-academic audiences such as teachers. Providing open access to high-quality, digital education material via OERs (Klebl *et al*., 2010) and encouraging a form of social scholarship that fosters participants' engagement with these resources offers an alternative model of the peer-review process (Greenhow and Gleason, 2014). Fieldwork OERs are shared within the literature (Buckley *et al*., 2022; Horota *et al*., 2023; Nazarkulova and Strobl, 2023; McDougall, 2024), with a recognised need to invest in facilitator training to support OER uptake (Nazarkulova and Strobl, 2023).

Yet an approach to support the engagement with and review of OERs within the fieldwork education space has not previously been presented within the literature. Bioscience OER initiatives such as BIFoR in a Box and Virtual BIFoR from the Birmingham Institute of Forest Research (University of Birmingham, 2024) have fantastic reach with their free online learning platform for schools. BIFoR's approach encourages adoption of digitally enhanced fieldwork in woodland ecosystems, and while addressing a resource gap, it does little to address the knowledge and skills gap of facilitators. This research seeks to encourage practitioners' engagement with the OERs and build practitioners' competency and confidence to utilise and adapt these approaches. Drawing upon the principles of open scholarship (Veletsianos and Kimmons, 2015), this research will encourage greater engagement of practitioners with four digital approaches to fieldwork that are available as OERs, which are the outputs of education action research (Chapters 3 and 4). Recognising that the social construction of knowledge was an important theme during a study into the use of a mobile technology use within education with a cross-curricular participant group and that it influenced the motivation of the educators (Naylor and Gibbs, 2018), participatory discourse surrounding digital technology use will be considered and evaluated, with the intention of building a learner community amongst participants to support action (Long *et al*., 2019) which supports the integration of digital tools in practitioners fieldwork practice.

6.1.4 Research aim and objectives

The overarching research aim (RA) of this chapter is to share key findings and guidance within the wider fieldwork community to support the integration of digital tools within fieldwork (RA5). To address this aim, this chapter will focus on four research objectives (RO). First, this research will ask is the fieldwork community interested in adopting the digital tools developed, within their own fieldwork practice? (RO5.1). Second, are the developed digital resources a sources of inspiration to the fieldwork community? (RO5.2). Third, do workshop attendees have increased knowledge of the role of digital tools in fieldwork post-workshop? (RO5.3). Finally, how successful are participatory workshops as a method to disseminate educational research outputs (RO5.4).

6.2 Context underpinning the research

Working with HE students within Newcastle University, four digital approaches to fieldwork were developed (Virtual Field Trips (VFTs), Digital Field Notebook (DFN), Digital preparation resources, and Live broadcast). This research sought to use open research principles to share these outputs with the wider fieldwork community in and outside of HE via non-traditional, open, and creative methods. Participatory workshops were adopted to encourage collaboration between participants to support the integration of these approaches and OERs within a range of fieldwork contexts.

6.3 Methods

Recognising the potential for the use of the designed digital tools to be utilised in fieldwork outside of a single institution and the desire to research how to support the embedding of the tools within different contexts, a workshop was planned to disseminate the digital tools. Adopting open scholarship practice (Veletsianos and Kimmons, 2012; Greenhow and Gleason, 2014) and drawing upon guidance for the development of high-quality continuing professional development (CPD) (Collin and Smith, 2021), this workshop sought to address the identified need for continued teacher training on new technologies (Bartleton, 2018).

6.3.1 Participatory workshops

In reflecting upon the work of Orngreen and Levinsen (2017) the design of this workshop was as a research methodology, where the workshop was authentic, and aimed to meet the needs of participants, but also produced reliable and valid data related to the research questions via virtual synchronous data collection (Dubé *et al*., 2023).

Online video-conferencing tools offer a viable alternative to face-to-face workshops (Boland *et al*., 2021) with specific strengths in the context of this research as reaching a wide geographic spread of practitioners and removing travel costs for participants. However, it is recognised that this interaction needs to be carefully planned (Boland *et al*., 2021) and captured as these outputs are vital data for the researchers conducting the workshops (Orngreen and Levinsen, 2017; Binet *et al*., 2019).

In total, five workshops were hosted in February/March 2024 using either Zoom (four workshops) or Microsoft Teams (one workshop) with a digital collaboration tool (Padlet) used for synchronous sharing between participants. The Padlet remained active post-workshop, so participants had a record of the resources and discussions to refer to.

Inspired by the work of Odegaard *et al*. (2022) the workshops were designed to promote discussion and be collaborative in nature, with the researcher leading the workshop but also working with participants to facilitate discussion using Zoom/Teams chat, Padlet posts and audio discussion. The intent of the workshops was two-fold; (1) support practitioners in enhancing their fieldwork practice using digital tools and (2) gather quantitative and qualitative data to address research aims.

A guide to facilitating participatory workshops was developed and used to inform the design and delivery of the workshop (Figure 6.1). A copy of the training plan, participant information and safer spaces agreement for the workshops is included in Appendix 6.1.

Figure 6.1 A guide to facilitating participatory workshops.

The four Zoom workshops were not recorded, but the Teams workshop was recorded so that the organisation (Field Studies Council (FSC)) could share internally with colleagues. These subsequent views of the recorded workshop did not form part of this evaluation.

6.3.2 Recruiting research participants via social media, membership newsletters and direct contact

Recruitment of participants to the workshops was conducted via social media, membership newsletters and direct contact with four fieldwork providers. The participatory workshops were shared via social media (Twitter/X and LinkedIn). The social media assets and engagement metrics for the recruitment post are summarised in Appendix 6.2. Details about the workshop were shared in two email newsletters to their members (Royal Geographical Society- Education and the Geographical Association). Four fieldwork providers (Skern Lodge, Loch Ranza, Cranedale, and FSC) were contacted directly using personal contacts. A specific training workshop was scheduled for FSC staff that was not advertised outside of the organisation.

6.3.3 Workshop activities and engagement metrics

From the five workshops, engagement and participation were measured by contributions made by participants (Table 6.1). Audio comments made by the participants did not form part of this evaluation. This was communicated to participants and ensured that there was a space for open dialogue that did not form part of this research.

During the workshop two activities resulted in outputs. The first was a fieldwork mapping activity, where participants considered the student and teacher roles of each of their fieldwork occasions currently offered and mapped these. This enabled participants to visualise the progression of fieldwork within their individual contexts and identify potential gaps or opportunities where digital tools could enhance their fieldwork provision. These reflections then informed the second output, Digital Action Plans (DAPs) that participants were asked to complete in the workshops.

The DAPs enabled participants to identify an 'Area of Development' and share their reasoning behind why this area of development had been chosen. Participants could then identify objectives and plan the actions needed to meet those objectives. The completion of DAPs was designed to be a mutually beneficial process with the areas of development, subsequent justification and actions offering vital information from a research context on the 'interest in adoption of digital tools' and 'the workshop as a source of inspiration'. Participants also had dedicated time to consider their actions arising from the workshops, and how it might be integrated into their own area of practice. The DAPs had space for participants to record progress. A blank DAP is presented in Appendix 6.3.

Table 6.1 Engagement metrics from the participatory workshops.

Contributions	Outputs
Number and content of Padlet posts in response to three prompts: 1. What are your opinions on embedding digital tools in fieldwork? 2. What digital tools are you aware of and what is their purpose? 3. What is your best learning takeaway and how will you use what you have learned? Number and content of Zoom chat comments throughout the workshop in response to participants engagement and reflections on the four digital tools shared.	Number and content of fieldwork mapping and identifying gaps activity (photo uploaded to Padlet). Number and content of Digital Action Plans (DAPs) (uploaded to Padlet).

6.3.4 Post-workshop survey

Post-workshop, all registered participants were contacted with a link to an anonymous survey hosted by JISC Online Surveys. Open and closed questions were included in the survey, with all questions optional. The survey asked participants to disclose the number of years facilitating fieldwork, as well as questions inviting participants to review their existing fieldwork practice, views on the use and value of digital tools in fieldwork education, critical reflection of the digital tools shared within the workshop and actions to enhance existing fieldwork practice using the digital tools. A copy of the survey is included within Appendix 6.4.

6.3.5 Ethics

The participatory workshop and post-workshop survey received ethical approval from Newcastle University on 25/01/2024 Ref: 41815/2023.

During the registration process, all participants received a Participant Information Sheet and Safer Spaces Agreement. The Safer Spaces Agreement detailed the guidelines and expectations about creating an inclusive, welcoming, and respectful online training environment. This Participant Information Sheet enabled participants to give informed consent to participate in the workshop, which formed part of the methodology of this research.

From the perspective of a training workshop, the researcher acted as a host who prioritised participant need during the training workshop. From the research perspective, the participants, along with their contributions and outputs, become part of the research design and data.

6.3.6 Data Analysis

Quantitative data from the post-workshop survey were analysed using descriptive statistics where percentages were used to summarise the data related to:

- Participants' responses to their *'Current use'* and *'Likelihood of future use'* of the four digital tools to give an indication of participants interest of adoption (RO5.1).
- Participants' self-assessment of their knowledge post-workshop in response to the question *'The training workshop has increased my knowledge of each of the four digital approaches'* (RO5.3).
- Participants' review of their *'satisfaction of the workshops'* to give an indication of the success of the workshops (RO5.4).

SPSS (IBM SPSS Statistics for Windows, version 29.0.1.0 (171) (IBM Corp., Armonk, N.Y., USA) was used to undertake statistical analyses. Spearman Rank Correlation Co-efficient was undertaken to determine if there was a statistically significant correlation between participants number of years facilitating fieldwork and their self-assessed experience of using digital tools in fieldwork. A Kruskal-Wallis *H* test was conducted to determine if participant reflections on their *'Current use'*, '*Likelihood of future use'* and response to the question *'The training workshop has increased my knowledge of each of the four digital approaches'* were statistically different between the four digital approaches (DFN, digital preparation resources, VFTs and live broadcasting). Post-hoc testing using multiple Mann-Whitney-*U* tests investigated which of these groupings were different from each other.

Qualitative data from individual questions within the post-workshop survey, Padlet/Zoom comments and DAPs were all analysed separately. The six-stage analytical guidance (Braun and Clarke, 2019; 2020) was used to inform the reflexive thematic analysis undertaken within this research, with the researcher actively involved in producing themes from the data.

- To determine participants' interest in adoption of the digital tools (RO5.1), sentiment analysis was conducted to categorise participant views pre- and post-workshop on their '*opinions on embedding digital tools in* fieldwork?'. Views were categorised as being positive or negative with inductive content analysis undertaken to determine the frequency of individual sentiment comments.
- Inductive content analysis conducted on participants' responses in the post-workshop survey responses to *'How you will use what you have learned?'* to determine participants' interest in adoption of the digital tools (RO5.1).
- To determine whether the workshops were a source of inspiration (RO5.2), reflexive thematic analysis was undertaken on the Zoom/Padlet comments on each of the four digital approaches.
- Reflexive thematic analysis was used to analyse participants responses to the Padlet prompt 'Key things learned' to determine whether the workshops increased participants knowledge of digital fieldwork tools (RO5.3).
- Participants DAPs were reviewed with inductive content analysis used to categorise and determine frequency of participants actions arising from the workshop to provide evidence on whether the workshops were a source of inspiration (RO5.2).

Participant quotes are presented to illustrate the themes and outcomes shared within the findings.

6.4 Findings

6.4.1 Interest in adoption of digital tools within fieldwork

Interest in adopting digital tools within fieldwork can be obtained from the uptake for registration for the workshop. In total there were 157 registrations for the workshops with participants from universities, schools/colleges, fieldwork organisations and other (Figure 6.2). Of the 47 registrations from HE, these represented 31 individual HE institutions. Of the 80 registrations from schools/colleges, these represented 78 individual institutions. Of the 19 registrations from fieldwork practitioners, these represented six individual organisations.

Participant numbers showcased a drop-off between registration, workshop attendance, completion of the post-workshop survey and completion of the DAP (Figure 6.2). There were

157 registrations, with 79 attendees across the five participatory workshops. Sixty-one percent of attendees completed a post-workshop survey and 32% of attendees completed and submitted a DAP (Figure 6.2).

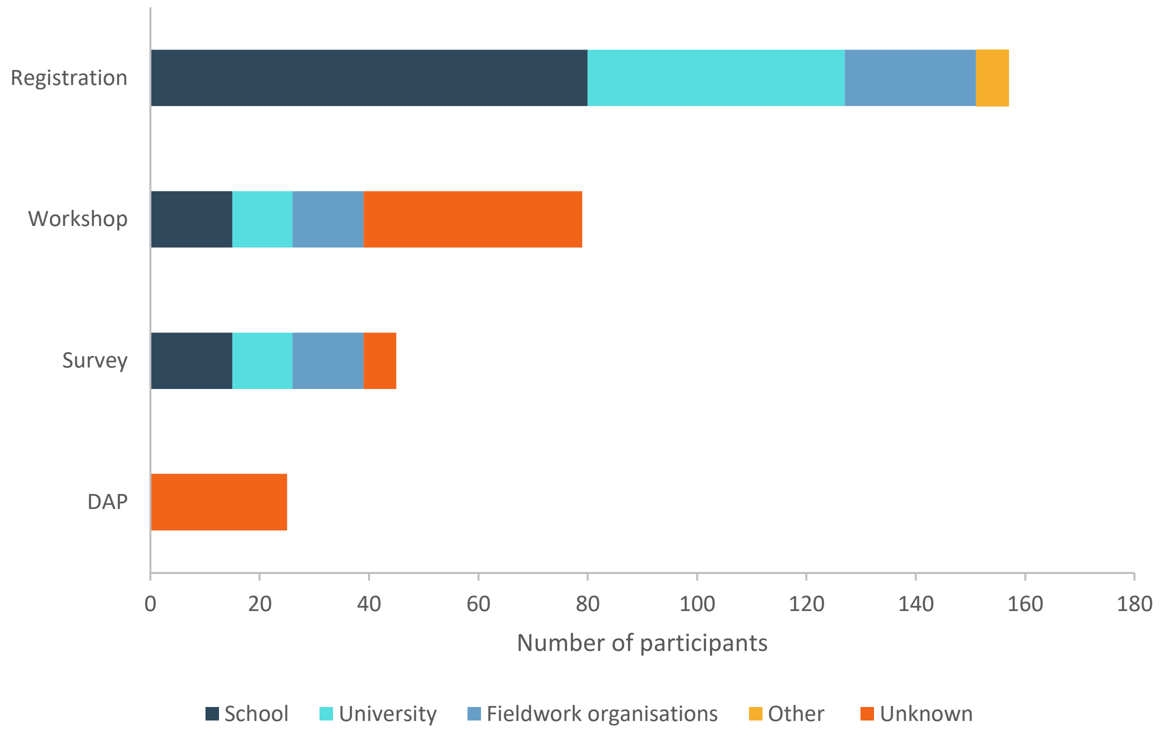

Figure 6.2 Participant recruitment numbers at different aspects of the participatory training workshops (registration, workshop, survey, Digital Action Plan (DAP)). Where known, the proportion of participants from Universities, Schools/Colleges, Fieldwork organisations and Other are identified. Participants were not asked to disclose whether they were from Universities, Schools/Colleges or Fieldwork organisations on the DAP, resulting in all DAPs classified as 'Unknown'.

Workshop registrations were from 12 countries, with 92% of participants from the UK with good geographic spread (Figure 6.3). The remaining registrations were from 11 other countries; India, Pakistan, USA, Ethiopia, Oman, Democratic Republic of Congo, Czech Republic, Republic of Ireland, Türkiye, Kazakhstan and Poland.

Figure 6.3 UK geographic spread of workshops registrations (n = 140), with colour referring to the sector of the registration (Blue = University, Red = School/College, Green = Fieldwork practitioner, Purple = Other).

The workshop attracted experienced practitioners, with 81% of respondents of the post-workshop survey having more than five years' experience of facilitating fieldwork (Figure 6.4). Yet interestingly, despite this experience in facilitating fieldwork, participants had a range of experience of using digital tools in fieldwork; with 33% describing themselves as a novice, 19% advanced beginner, 27% competent, 17% proficient and 4% expert (Figure 6.4). However, there was no statistically significant correlation between the number of years facilitating fieldwork and participants self-assessed experience of digital tools (Spearman Rank Correlation Co-efficient, $r_s = 0.147$, $df = 46$, $P = 0.318$).

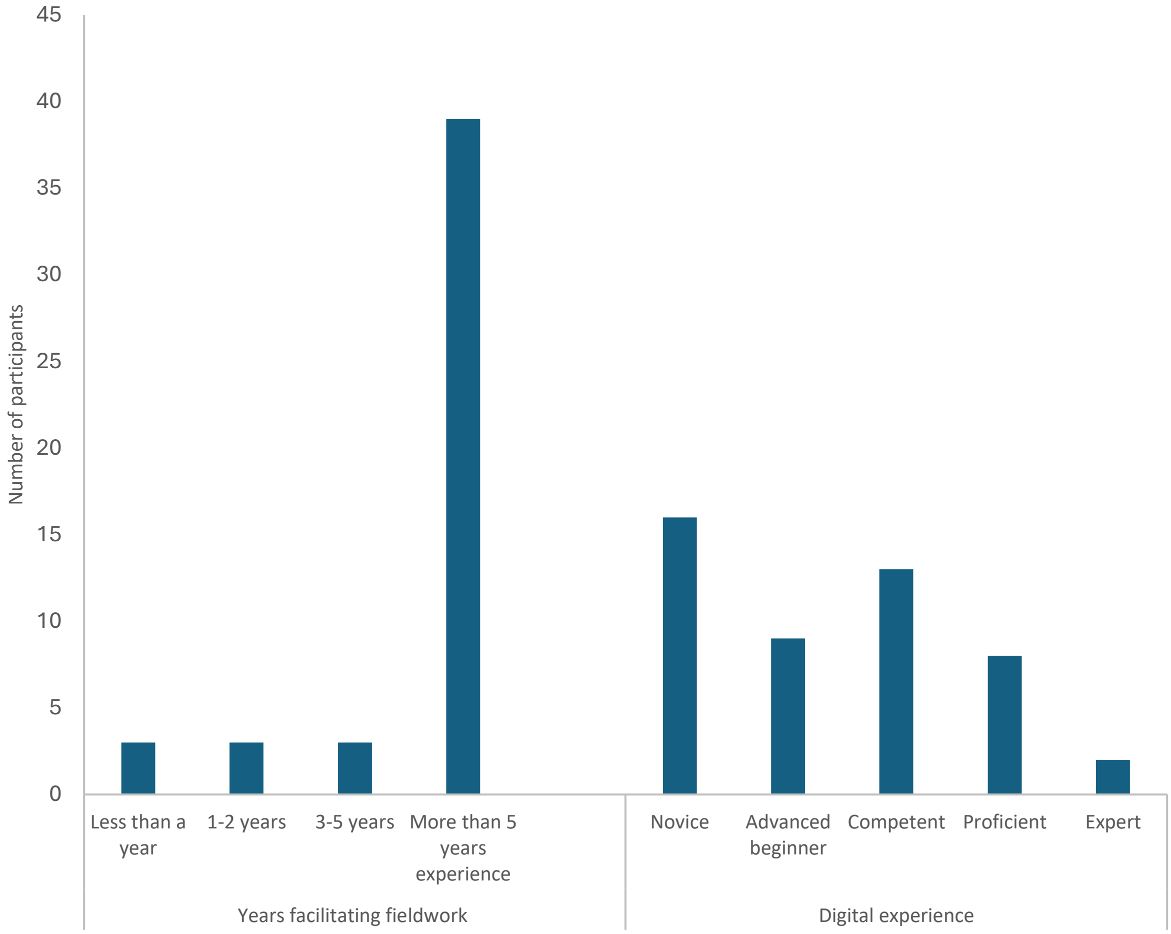

Figure 6.4 Post-workshop survey response to both 'number of years facilitating fieldwork' (n = 48) and 'self-assessed experience of using digital tools in fieldwork' (n = 48).

Although verbal discussion about the digital tools was not recorded, engagement metrics such as the total number of comments posted on Paddlet and in the Zoom chat in response to the questions and prompts within the workshop were recorded. Table 6.2 summarises participants' engagement with these prompts.

Although engagement metrics do not indicate direct interest in adoption of the digital tools it is interesting to note that both the VFT and the digital preparation resources promoted some of the highest number of comments, 78 and 76 comments respectively. It should be recognised that overall, the number of posts/comments decreased as the 90-minute workshop progressed (Table 6.2); this is likely due to a drop in engagement levels of participants.

Table 6.2 Total number of Padlet posts and Zoom comments across all five workshops categorised by question or prompt used in the participatory workshop.

Order in workshop	Question/prompt	Number of posts (Padlet) /comments (Zoom/Teams)
1.	What are your opinions on embedding digital tools in education?	77
2.	What digital tools are you aware of and what is their purpose in fieldwork?	69
3.	Virtual Field Trips (VFTs) resource.	78
4.	Preparing for fieldwork resource.	76
5.	Digital Field Notebook (DFN) resource.	53
6.	Live broadcast approach.	48
7.	Best learning takeaway. How will you use what you have learned?	35
n/a.	General comments.	57
n/a.	Interaction between participants.	35

The post-workshop survey asked participants to reflect on their current use of the four digital tools shared within the participatory workshop on a Likert scale of; '1. *Every time', '2. Almost every time', '3. Occasionally/sometimes', '4. Almost never' and '5. Never'*.

Digital preparation resources were the only digital tool that had high numbers of participants who used the tool *'1. Every time'* or *'2. Almost every time'* (13 responses) while live broadcast (one response), DFNs (one response) and VFTs (four responses) all had very low numbers of responses who used the digital tools *'1. Every time'* or *'2. Almost every time'*. Both live broadcast and the DFN were a particular novel approach and had very high numbers of participants who had '5. *Never*' or '4. *Almost never*' used these tools, 44 and 38 responses respectively (Figure 6.5).

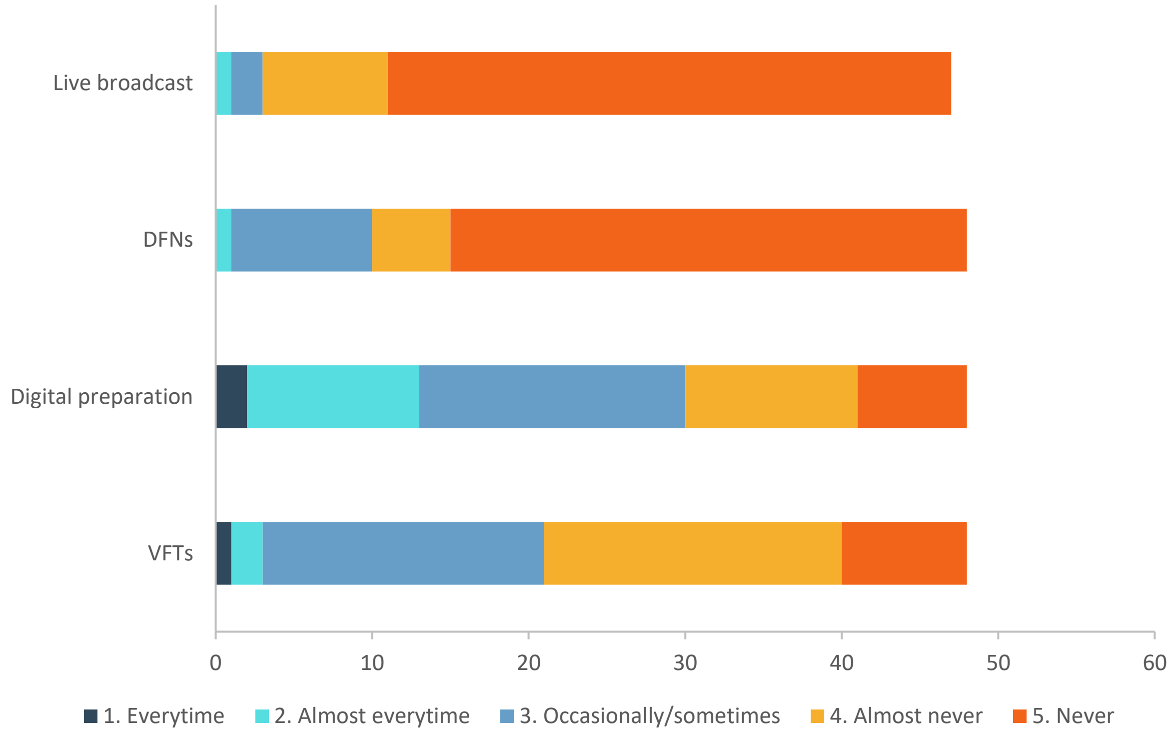

Figure 6.5 Participants post-workshop response reflecting on how often they already use each of the digital approaches (live broadcast, Digital Field Notebooks (DFNs), digital preparation resources, Virtual Field Trips (VFTs)) in their current teaching (n = 48).

A Kruskal-Wallis *H* Test showed there was a statistically significant difference in participant responses between at least one of the four digital fieldwork approaches (H = 64.50, n = 48, P < 0.001).

Mann Whitney-*U* pairwise comparisons indicated that the approaches of Digital Preparation and VFT were significantly different from the approaches DFN and Live Broadcast (Table 6.3).

Table 6.3 Median Likert response of each digital approach (with range) and Mann-Whitney- U Pairwise comparisons of the groupings of all four digital approaches indicating between which digital approaches there is a significant difference between participant responses assessing their current use of the approach; 'How often do you use each of the digital fieldwork approaches?'

Digital approach	Median Likert response	Range
VFTs.	4	4
Digital Preparation.	5	4
DFN.	5	3
Live Broadcast.	5	3
Paired grouping of digital approach	**Significance**	**Adjusted significance (* significant difference)**
Digital Preparation and VFTs.	0.129	0.775
Digital Preparation and DFN.	<0.001	<0.001*
Digital Preparation and Live Broadcast.	<0.001	<0.001*
VFTs and DFN.	<0.001	<0.001*
VFTs and Live Broadcast.	<0.001	<0.001*
DFN and Live Broadcast.	0.269	1.000

Participants were asked to reflect on the likelihood of adopting the digital tools into their own practice on a Likert scale of; '1. *Extremely likely', '2. Likely', '3. Neutral', '4. Unlikely' and '5. Extremely unlikely'*.

Three of the digital tools had very high numbers of participants who shared that they were either *'1. Extremely likely'* or *'2. Likely'* to adopt the approach into their own teaching. Ninety-two percent of participants said that would be *'1. Extremely likely'* or *'2. Likely'* to adopt the digital preparation resources, 88% of participants said that they would be *'1. Extremely likely'* or *'2. Likely'* to adopt the VFTs and 83% of participants said that they would be *'1. Extremely likely'* or *'2. Likely'* to adopt the DFN (Figure 6.6). Live broadcast was a digital approach that had a very mixed picture regarding participants proposed adoption of the tool. Twenty-seven percent indicated that they were *'4. Unlikely'* or *'5. Extremely unlikely'* to adopt the tool, 33% were *'2. Likely'* to adopt the tool and 40% remained *'3. Neutral'* on the approach (Figure 6.6).

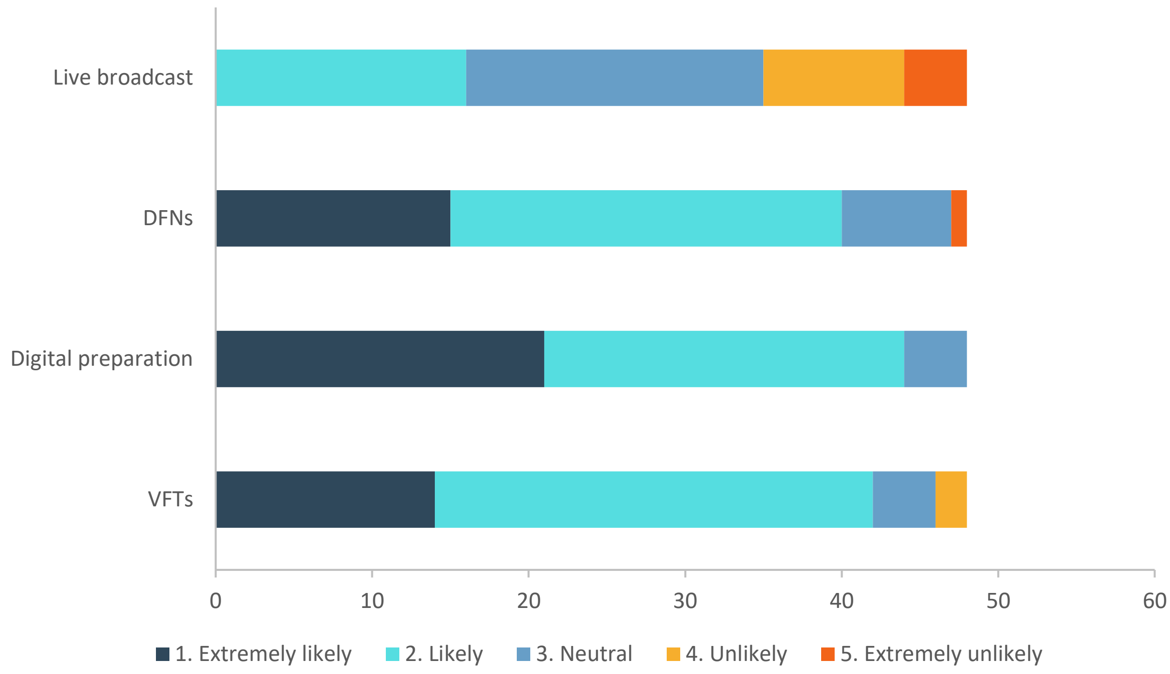

Figure 6.6 Participants post-workshop response reflecting on how likely after the workshop they are to adopt each of the digital fieldwork approach (live broadcast, Digital Field Notebooks (DFNs), digital preparation resources, Virtual Field Trips (VFTs)) (n = 48).

A Kruskal-Wallis *H* Test showed there was a statistically significant difference in participant responses between at least one of the four digital approaches (H = 59.33, n = 48, P = < 0.001).

Mann Whitney-*U* pairwise comparisons indicated that the approach of Live Broadcast was significantly different from the approaches of DFN, Digital Preparation and VFTs (Table 6.4).

Table 6.4 Median Likert response of each digital approach (with range) and Mann-Whitney-U pairwise comparisons of the groupings of all four digital fieldwork approaches. Indicated between which digital approaches there is a significant difference between participant responses assessing the likelihood of adopting each of the approaches; 'How likely after this workshop are you to adopt each of the digital fieldwork tools?'

Digital approach	**Median Likert response**	**Range**
VFTs.	2	3
Digital preparation.	2	2
DFN.	2	4
Live broadcast.	3	3
Paired grouping of digital approach	**Significance**	**Adjusted significance (* significant difference)**
Digital Preparation and VFTs.	0.188	1.000
Digital Preparation and DFN.	0.162	0.973
Digital Preparation and Live Broadcast.	<0.001	<0.001*
VFTs and DFN.	0.936	1.000
VFTs and Live Broadcast.	<0.001	<0.001*
DFN and Live Broadcast.	<0.001	<0.001*

In analysing participants' interest in adopting the tools, it is vital to consider their views pre- and post-workshop. At the start of workshop, participants were asked an open question with time to add their responses to the question prompt anonymously via Padlet. Seventy-seven individual comments were made in response to: '*What are your opinions on embedding digital tools in fieldwork?'* Some comments expressed both positive and negative opinions of digital tools in fieldwork. In analysing the sentiment and theme of these comments, 63 views that could be classified as positive were shared and there were 41 that could be classified as negative (Figure 6.7).

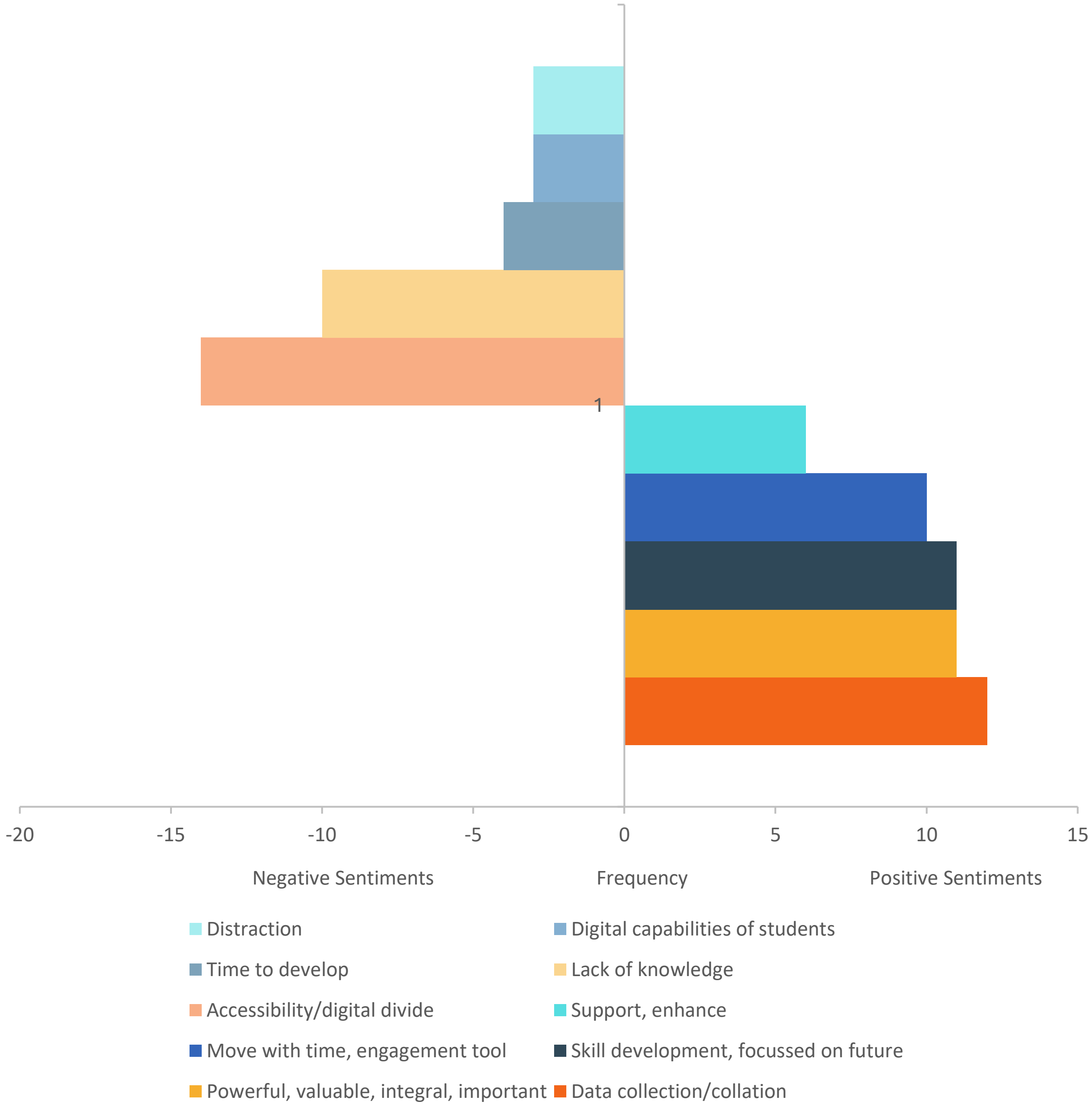

Figure 6.7 The top five highest frequency positive and negative sentiments expressed by participants at the start of the workshop in response to the question; 'What are your opinions on embedding digital tools in fieldwork?'

Accessibility and the digital divide were the highest frequency negative view (14 participants) on embedding digital tools in fieldwork (Figure 6.7; Table 6.5).

Ten participants were concerned about their own lack of knowledge in these aspects (Figure 6.7; Table 6.5). The highest frequency positive view (12 participants) related to the role of digital tools to make data collection and data collation easier (Figure 6.7; Table 6.5). Eleven participants recognised that the digital tools were powerful, valuable, and integral to fieldwork with skill development also a key positive view of embedding digital tools (11 participants) (Figure 6.7; Table 6.5).

Table 6.5 Participant quotes to illustrate positive (yellow) and negative (blue) sentiments expressed at the start of the workshop in response to the question; 'What are your opinions on embedding digital tools in fieldwork?'

Sentiment	Participant quote
Accessibility.	*"Accessibility. Really like the idea of embedding these tools, but constantly concerned about the ability of all students to access these if they don't have the money for devices, or if school don't have the money to supply them." Anonymous Padlet comment, workshop 1.*
Lack of knowledge.	*"Find it difficult to really come across to students as if I know what I am doing with the tools - you need to be really confident in using them to help the kids use them well - however the only way to get this experience is to use them often and get stuck in - which is difficult when you don't know them well." Anonymous Padlet comment, workshop 1.*
Data collection/collation.	*"Digital tools are good for supporting fieldwork. They work well to help speed things up, create visual representations of data." Anonymous Padlet comment, workshop 3.*
Skill development.	*"Can definitely enhance and is what is used in the real world, if people are collecting tree data for a job they're using tech so why aren't we training our students for future work." Anonymous Padlet comment, workshop 2.*

After the workshop participants were asked to reflect again on their views of embedding digital tools in fieldwork. In summary, 57 opinions that could be categorised as positive and 19 as negative were shared.

Pre-workshop negative opinions made up 39% of the total, and post-workshop negative opinions made up 25% of opinions (Figure 6.8).

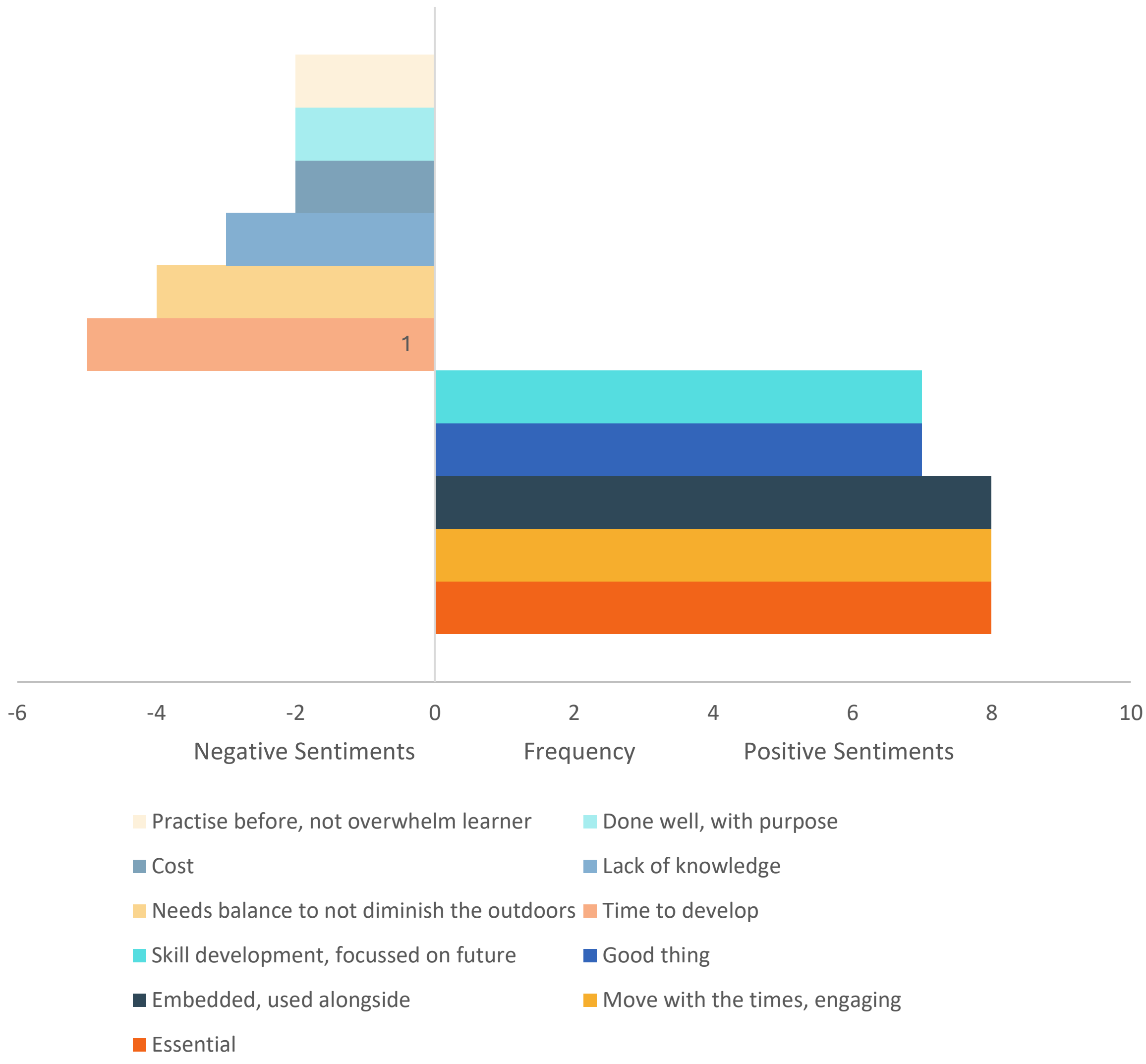

Figure 6.8 The top five highest frequency positive and negative sentiments expressed by participants in the post-workshop survey in response to the question; 'What are your opinions on embedding digital tools in fieldwork?'

Positive views post-workshop gave an indication of participants interest in adopting the digital tools; with the digital tools being viewed as essential (eight participants), moving with the times (eight participants) and that they should be embedded and used alongside existing fieldwork (eight participants) (Figure 6.8; Table 6.6).

But although valuable and essential, barriers to the adoption of digital tools in fieldwork remain, with the highest frequency negative view related to the time to develop the approaches (five participants) (Figure 6.8; Table 6.6).

Probably the best indication of whether participants had an interest in adopting digital tools in fieldwork can be gathered from participants sharing how they would use what they have learned in the workshops (Figure 6.9).

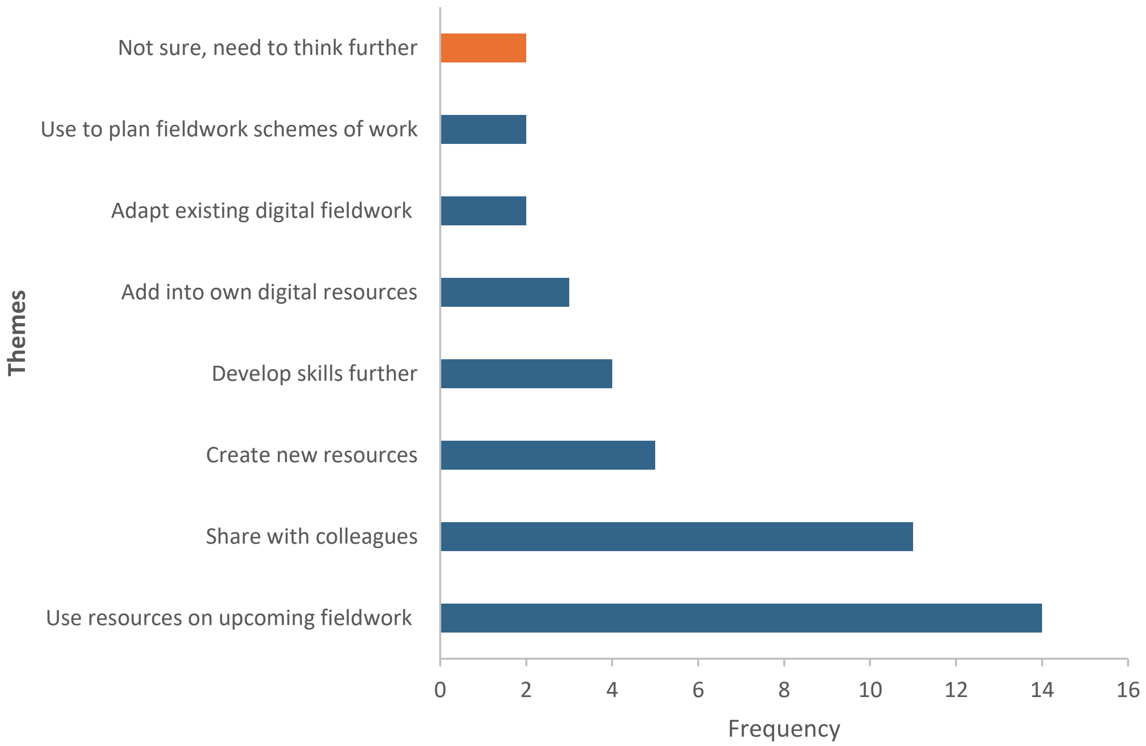

Figure 6.9 Participant respondents (n = 38) in the post-workshop survey to the question; 'How will you use what you have learned?' Blue indicates purposeful interest in adopting the digital tools within their own fieldwork. Orange indicates a response which shows a lack of clear interest in adoption of the digital tools.

Just over a third of participants indicated that they would use the digital resources, on specific upcoming fieldwork with their students (Figure 6.9). There were 11 responses where participants indicated that they wished to share what they had learned with their colleagues (Table 6.6). There were only two responses where participants discussed 'not knowing' or 'needing to think further' about how they would use what they have learned. Four respondents discussed the need to develop skills further before using and embedding and show that the single workshop approach may not be enough to fully develop the skills needed (Table 6.6).

Table 6.6 Participant quotes to illustrate sentiments expressed in the post-workshop survey in response to the questions; 'What are your opinions on embedding digital tools in education?' and 'How will you use what you have learned?'

Survey question	Participant quote
'What are your opinions on embedding digital tools in fieldwork?'	*"Important for students in the digital age we are now in to understand the possibilities." Post-workshop survey F68.*
	"It's a no brainer. This is the world that we live in. Technology needs to be used. However, training for delivery has to form part of that. Funding issues for time and resources to upskill, are the barrier to those delivering fieldwork." Post-workshop survey F60.
	"It is worthwhile. Although the time needed to initially implement changes may be daunting, it's a challenge I'm feeling much more up to with the learning that I've engaged after this workshop." Post-workshop survey F96.
'How will you use what you have learned?'	*"I will look to develop my skills in the use of some of the platforms that were discussed." Post-workshop survey F89.*
	"I will share what I've learned with colleagues who I am sure will be very inspired. I will also start a conversation at my university about the possibility of doing live broadcasts and I will also reconsider our use of virtual notebooks." Post-workshop survey F103.

6.4.2 Source of inspiration

Although the participatory workshop shared four digital approaches via OERs, one of the key aims of the workshop was to encourage discussion and collaboration about how these digital tools could be tailored and adapted to suit individual participants' contexts. During the workshop participants reflected upon the four digital approaches and shared suggestions of new ideas or new ways of using these approaches (Figure 6.10).

Figure 6.10 Sources of inspiration identified from the reflexive thematic analysis of participants' Zoom/Microsoft Teams comments on each digital approach (Digital Field Notebook (DFN), Virtual Field Trip (VFT), Digital preparation resources (Prep) and the Live broadcast).

The VFT was the largest source of inspiration with 13 new ideas or new ways to use shared (Figure 6.10). Participants shared a desire to replicate the VFTs in other environments that they conducted fieldwork in already (Table 6.7). Participants also reflected on different ways they might use the VFT in their teaching, with some commenting on how they would use technology to bring the VFT to life (Table 6.7), while others shared the pedagogy that they would adopt to embed the VFTs into their own practice (Table 6.7). Eleven new ideas or new ways to use the live broadcast were shared (Figure 6.10). Workshop participants reflected upon different purposes of the live broadcast which included the potential for live broadcast in marketing, outreach, and activism within education settings (Table 6.7). Eight new ideas or new ways to use were shared when reflecting upon the DFN (Figure 6.10). Workshop participants identified value in tailoring the DFN to suit individual fieldwork enquiries by adding quantitative data specific to the fieldwork and including secondary data. Participants also shared the potential for the DFN to collate and present temporal data (Table 6.7). Increased student involvement in the creation of the DFN was another suggestion (Table 6.7. Workshop participants also shared how they might use the DFN themselves during their fieldwork teaching (Table 6.7). Eight new ideas or new ways to use were shared when reflecting upon the digital preparation resources (Figure 6.10). Interestingly workshop participants identified a broader audience for the digital preparation resources, with potential use with parents, early-career teachers and to offer a CPD training opportunity for facilitators of fieldwork (Table 6.7). Workshop participants recognised that the preparation resources could be easily adapted and tailored to suit individual contexts, and the associated benefits of doing so (Table 6.7). Although the digital preparation resources are designed to support all students develop fieldwork knowledge, skills, and confidence prior to fieldwork, workshop participants identified value in sharing the resources with wider teams within their settings to support students (Table 6.7).

Table 6.7 Participant responses illustrating Virtual Field Trips (VFTs), Live broadcasts, Digital Field Notebooks (DFNs) and digital preparation resources as a source of inspiration.

Virtual Field Trips (VFTs).	*"At first I thought, I don't do coasts! But then as I was looking through the items thought how I might attempt to produce a similar set of items from a personal field trip." Zoom comment workshop 1.*
	"Be good for areas here like mangrove ecosystems where access is difficult, to help add extra detail. Students can still visit, but virtual trip can extend experience." Zoom comment workshop 4.
	"I like the access to 360° images as although Google Earth is good, you can incorporate with VR headsets." Zoom comment workshop 2.
	"For advanced higher geography it would work really well in developing both the skills needed and the knowledge. I would do the same flipped class - get them to do certain sections themselves and then bring together as a group." Zoom comment workshop 5.
Live broadcast.	*"We do live links sometimes (between our uni and schools) but currently these are classroom to classroom- it would be a great step up to have researchers (or indeed students) in the field." Zoom comment workshop 5.*
	"Student activism and ownership of issues can be displayed well to other students both locally, nationally, internationally; student or not. Sharing concerns and desires for change etc." Zoom comment workshop 4.
	"Great for open evenings too." Teams comment workshop 3.

	"I think this sort of thing would be great as a promotional tool for the subject generally to put on the school subject area. Something I'll be doing next week, and I think the students would be keen to get involved, given this world of TikTok etc!" Zoom comment workshop 2.
Digital Field Notebook (DFN).	*"The dashboard is a great way of sharing studies within a cohort. I can see it being useful to show year on year changes in vegetation/habitats." Zoom comment workshop 4.*
	"Good for getting a record of change in the fieldwork location, year on year." Zoom comment workshop 4.
	"I think I'd like to try giving a very bland version for a pilot investigation and asking students to be thinking about which questions it would have been good to ask once they've found gaps in their analysis so they can then write their own." Zoom comment workshop 5.
	"If used well by student, (it) can be used to monitor students doing fdwk (fieldwork) live in real time, who is working or not?" Zoom comment workshop 2.
Digital preparation resources.	*"Really useful for teachers to use as CPD / refresh our perspectives on fieldwork." Zoom comment workshop 1.*
	"Super useful to help departments or colleagues or trainees who may have less idea about how and why to do fieldwork - really excellent resource to help with planning trips as well." Zoom comment workshop 1.
	"Really like the collection of so many different aspects of running, delivering and participating in fieldwork. Would be awesome for PGCE courses." Teams comment workshop 3.
	"Could be shown to parents in parents info evening." Teams comment workshop 3.

	"Having a resource that can be 'dragged and dropped' into lots of things does offer great benefits in efficiency but also in consistency." Zoom comment workshop 4.
	"To illustrate field sites and accommodation etc to the Disabilities team so they can help us support specific students on residential trip (Access Audit)." Zoom comment workshop 1.

Although these new ideas and new ways of using the tools can be viewed in a positive manner showcasing that the digital approaches shared were a source of inspiration, the DAPs that some workshop participants completed give a stronger indication of how this inspiration can be utilised. Participants were given 20 minutes at the end of the workshop to produce a DAP to reflect upon areas of development, objectives, and actions to meet objectives post workshop. In total 25 DAPs were submitted to Padlet (Figure 6.11).

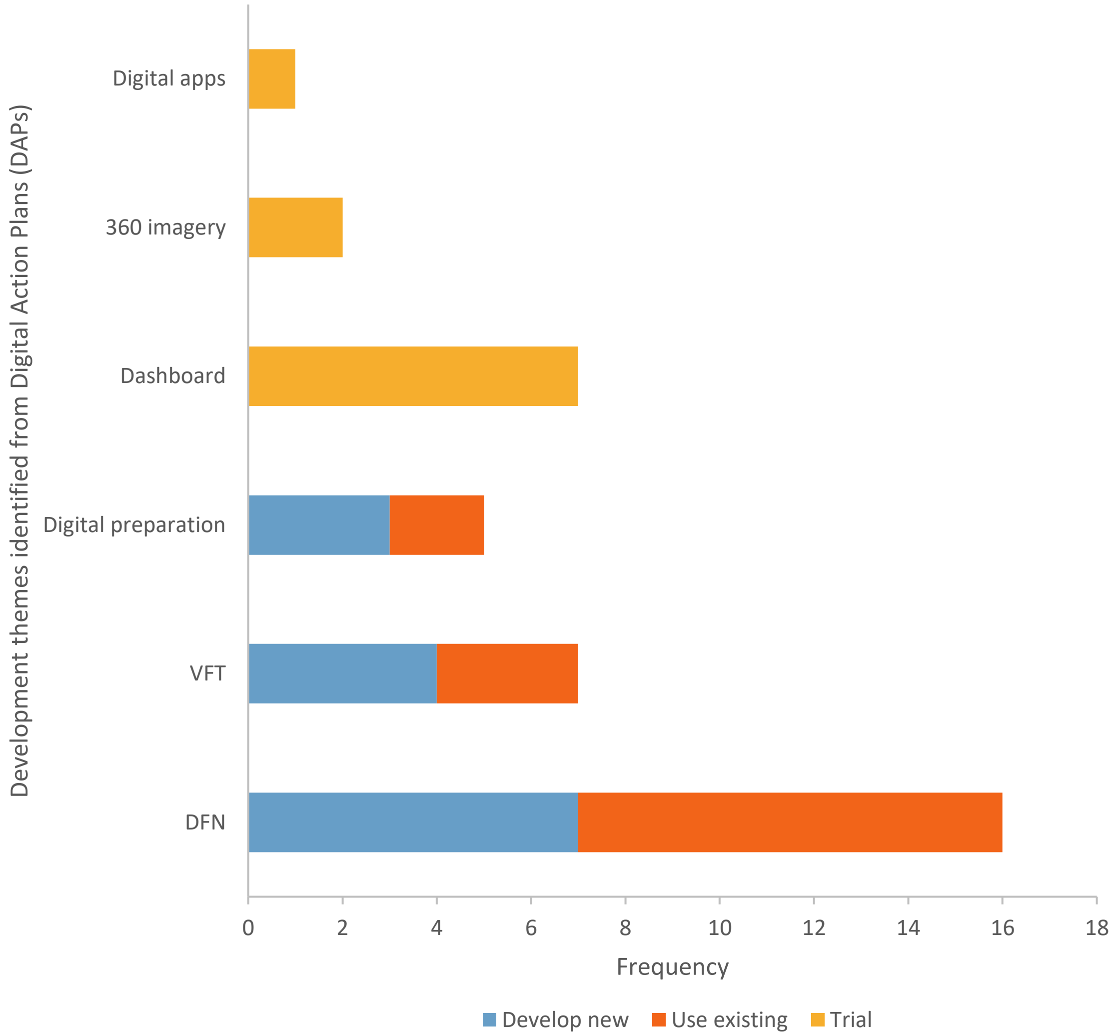

Figure 6.11 Inductive content analysis of the identified development areas post-workshop shared via participants' digital action plans (DAPs) (Digital Field Notebook = DFN; Virtual Field Trip = VFT).

The DFN was the most popular approach that participants wished to develop within their own practice. Although seven participants wished to use the existing DFN shared within the workshop, nine participants wanted to develop their own version to suit their own fieldwork locations and enquiries (Figure 6.11). One DAP shared how they envisioned a DFN could be used by students during urban fieldwork (Table 6.8). Seven participants wished to develop VFTs into their own practice, with three participants using the existing sand dune and salt marsh VFT shared in the workshops and four participants wishing to develop their own VFTs. One DAP reflected upon the purpose of developing their own VFTs (Table 6.8). Five participants wished to develop digital preparation resources within their fieldwork practice. Three participants wished to use the generalised preparation resources shared within the workshop, while two participants wished to develop their own tailored and/or specific versions. One DAP reflected upon the proposed use of the digital preparation resources (Table 6.8). Participants also commented on the desire to develop digital skills by trialling some of the digital tools (Dashboards, 360 imagery and apps) used to develop the fieldwork approaches within their DAPs (Table 6.8).

Table 6.8 Examples of participants Digital Action Plans (DAPs) illustrating development areas post-workshop. (Digital Field Notebook = DFN; Virtual Field Trip = VFT).

Development area	Participant quote
Develop new DFN.	*"I have used Survey 123 in my previous schools with good levels of success. I want to embed this into my new school to enable students to see live data and get to the analysis of fieldwork data more quickly. Create a dashboard to display data collected during urban fieldwork." DAP 4.*
Develop new VFT.	*"To enhance the fieldwork experience of those who do not attend the Malham river fieldwork. StoryMap created to share with students who did not attend the fieldwork." DAP 1.*
Use existing digital preparation resources.	*"To reduce anxiety for students and reduce time in field for teaching skills. There is a lot to consider to safely take students on fieldwork trips, either day or residential, and the potential for cognitive overload of students means they might not get the most from the trip." DAP 20.*
Trial digital tools.	*"Develop skills in 360° photography to enhance. As would like to use 360 photography to enhance existing resources." DAP 11.*

6.4.3 Increased knowledge of digital fieldwork tools

All participants completing the post-workshop survey (n = 48) said that they had learned something new in the workshop. When asked to share some of the key things that were learned during the workshop, three main summary themes were identified; 1. Purpose of the tool, 2. How to use the digital tool in their own practice and 3. Knowledge of specific tools (Figure 6.12).

Figure 6.12 Summary themes of the reflexive thematic analysis of participants' responses to 'key things learned during the workshop' (n = 48).

The majority of learning occurred around specific digital tools shared within the workshop e.g. ArcGIS Survey 123 and ArcGIS Dashboards (Table 6.9). However, participants also reflected on their learning beyond just the technology itself to consider both how to use the tech within their fieldwork teaching, and reflections on the purpose of the tool itself (Table 6.9).

Table 6.9 Participant quotes exemplifying areas of key learning from the workshops.

Key theme	Participant quote
Specific tools.	*"The wide variety of tools which are available and some good practice which was modelled so I can more effectively replicate it." Post-workshop survey F96.*
	"Linking Survey123 to the dashboard." Post-workshop survey F93.
Purpose.	*"That good planning pays dividends later on. That students can be involved in the planning process more." Post-workshop survey F66.*
	"Ability of notebook to be so interactive. Great idea for students to create their own video revision tool." Post-workshop survey F68.
	"How it is possible to design accessible online resources that demonstrate different aspects of fieldwork - including, most importantly, research ethics - and so prepare students for their own fieldwork trips." Post-workshop survey F103.

Post-workshop, participants were asked if the training workshop had increased their knowledge of the digital tools (live broadcast, DFNs, Digital preparation and VFTs) on a Likert scale; '1. *Strongly disagree*', '2. *Disagree*', '3. *Neither agree or disagree*', *'4. Agree*' and '5, *Strongly agree'*.

One-hundred percent of participants shared that they *'5. Strongly agreed'* or *'4. Agreed'* that they had increased their knowledge of digital preparation resources. Ninety-four percent of participants shared that they *'5. Strongly agreed'* or *'4. Agreed'* that they had increased their knowledge of DFNs. Eighty-eight percent of participants shared that they *'5. Strongly agreed'* or *'4. Agreed'* that they had increased their knowledge of VFTs. Eighty-three percent of participants shared that they had *'5. Strongly agreed'* or *'4. Agreed'* that they had increased their knowledge of live broadcast (Figure 6.13).

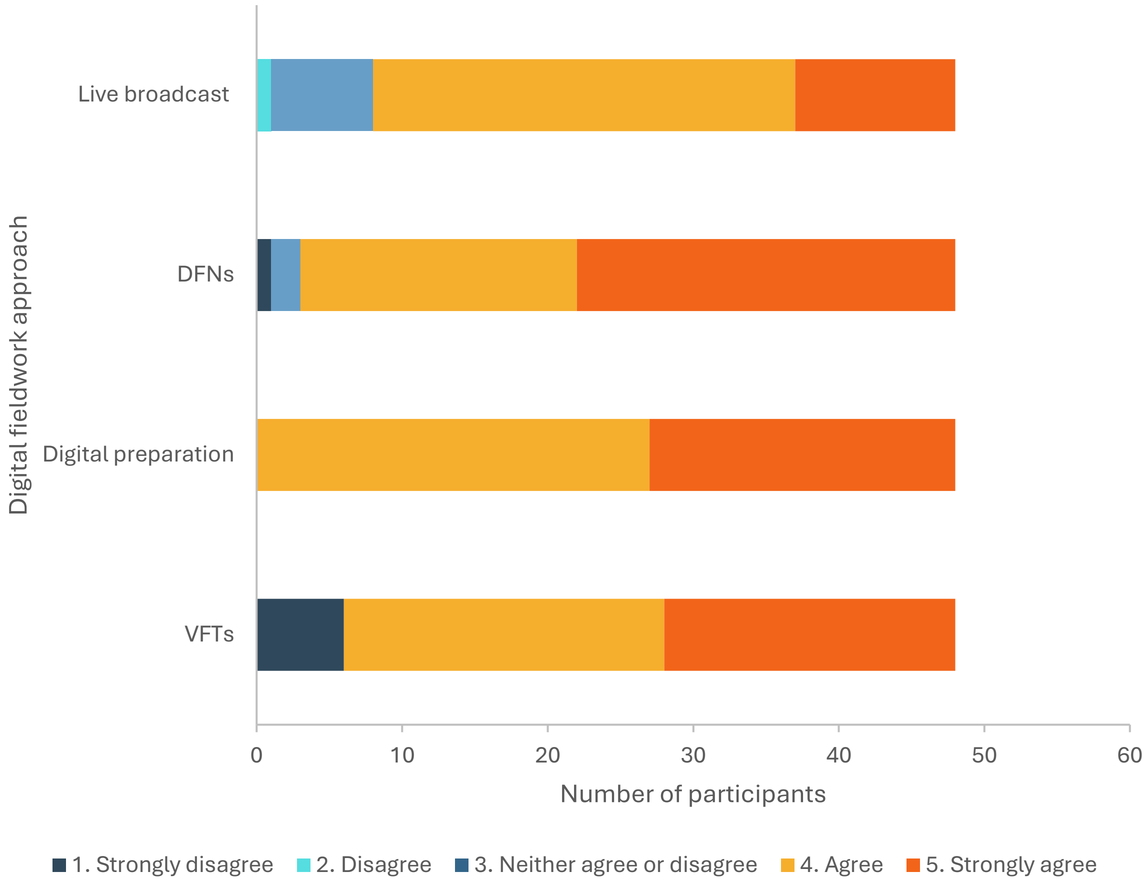

Figure 6.13 Participants post-workshop responses to; 'The training workshop has increased my knowledge of Live broadcast, Digital Field Notebooks (DFNs), Digital preparation resources and Virtual Field Trips (VFTs).' (n = 48).

A Kruskal-Wallis *H* test showed there was a statistically significant different in participant responses between at least one of the four digital fieldwork approaches ($H = 11.97$, n = 48, $P < 0.007$).

Mann Whitney-*U* pairwise comparisons indicated that the Live Broadcast approach was significantly different from the approaches DFN and digital preparation resources (Table 6.10).

Table 6.10 Median Likert response of each digital approach (with range) and Mann Whitney-U Pairwise comparisons of the groupings of all four digital fieldwork approaches indicating between which digital approaches there is a significant difference between participant responses to the statement; 'The training workshop has increased my knowledge of Live broadcast, Digital Field Notebooks (DFNs), Digital preparation resources and Virtual Field Trips (VFTs).'

Digital approach	Median Likert response	Range
VFTs.	4	4
Digital Preparation.	4	1
DFN.	5	4
Live Broadcast.	4	3
Paired grouping of digital approach	**Significance**	**Adjusted significance (* significant difference)**
Live Broadcast and VFTs.	0.084	0.502
Live Broadcast and Digital Preparation.	0.008	0.045*
Live Broadcast and DFN.	0.001	0.008*
VFTs and Digital Preparation.	0.347	1.000
VFTs and DFN	0.135	0.812
Digital Preparation and Live broadcast.	0.581	1.000

6.4.4 Success of workshops

Seventy-seven percent of participants who completed the post-workshop survey (n = 48) were *'very satisfied'* and 21% were *'moderately satisfied'*. The least and most useful aspects of the workshop shared within the post-workshop survey are summarised in Table 6.11.

Table 6.11 Least and most useful aspects of the workshop shared within the post-workshop survey (n = 48).

Least useful aspects	**Most useful aspects**
Lack of clarity on some of the workshop tasks. Volume of examples. Live broadcasting. Digital Field Notebook (DFN) is scary as quite new. More time needed for digital action plan. Some tools less practical for some age groups of students. Basics of tools. Not providing links to tools beforehand.	New ideas/resources. Adaptations/developments to resources. Discussion, sharing, collaboration. Examples, practical. StoryMaps. Digital Field Notebook (DFN) Virtual Field Trips (VFTs). Reflecting on own practice. Takeaways to implement.

The discussions and collaboration within the workshops were received positively (Table 6.12), with workshop participants pleased with the multiple modes of communication adopted (Anonymous Padlet posts, Zoom/Teams comments, and verbal communication) (Table 6.12). Participant comments reflected a sense of ownership arising from these discussions and their desire to embed outcomes of the workshop within their own fieldwork teaching and share back to the fieldwork community (Table 6.12). Some sought further collaboration amongst participants (Table 6.12). Participants also reflected upon ways to improve the workshop including a flipped learning approach to the delivery of the workshop, as well as extending the training offered within the workshop (Table 6.12).

Table 6.12 Participant feedback on the workshop shared within the post-workshop survey (n = 48).

Workshop feedback	Participant quote
Positive feedback on the workshop.	*"The chance to use some of the tools and to hear from other educators about how they might use them or work around possible issues." Post-workshop survey F96.*
	"All the material was well designed and structured and the presenter was very engaging. I also liked the interactive elements which allowed participants to express their ideas in a range of ways, not only verbally." Post-workshop survey F103.
	"Really well facilitated workshop, came out of it feeling very positive about the ideas we came up with and excited to try (to) get some of them involved in my practice." Post-workshop survey F78. *"Many thanks for the workshop, which I found thought provoking. I am keen to make use of the information provided. Happy to share the outcome." Post-workshop survey F84.*
Suggestions to improve the workshop.	*"I would have liked to have dived deeper in on other attendee's contributions to their written statements." Post-workshop survey F86.*
	"...links to the story maps might have been useful ahead of the meeting to allow more time to explore them ahead of the session." Post-workshop survey F78.
	"The workshop was great! I think this can be transformed into a series of workshops to train staff into different digital tools." Post-workshop survey F67.
	"As well as offering this as workshops / CPD credits, consider doing courses with a form of accreditation so educators can then evidence their proficiency." Post-workshop survey F96.

6.5 Discussion

Informed by principles of open scholarship, this research used participatory workshops to disseminate four digital fieldwork approaches to biosciences and GEES fieldwork practitioners within and outside of HE via OERs. It examined the extent to which these OERs were a source of inspiration for participants, increased their knowledge of digital tools in fieldwork and whether participants had an interest in adopting and/or adapting digital tools into their own practice.

6.5.1 Acceptance and adoption of digital technologies in fieldwork

Although the workshop attracted participants with a wide range of experiences of using digital tools in fieldwork, the workshop was overall useful to all participants, with high levels of workshop satisfaction. Additionally, all participants identified that they had learned something new, with participants giving an indication of their adoption of the tools by sharing how they might use what they had learned and via the DAPs. This sharing of their learning, and application to their own practice, shows that participants recognised the usefulness of the tools. Perceived usefulness has been found to be the strongest determinant of behavioural intention for technology acceptance in education (Teo, 2009), in the use of open-education resources (Kuo *et al*., 2024) and one of the key factors which determines overall acceptance of new technologies (Davis, 1989).

In summarising participants' comments on what they had learned, three themes were identified; knowledge of the digital tools themselves, how to use these tools and an understanding of the purpose of using these digital tools. These could also be described as technology knowledge, pedagogy knowledge and content knowledge. The TPACK framework identifies the complex and integrated knowledge needed to support technology integration in education (Koehler and Mishra, 2005; Voogt *et al*., 2013). Although frameworks exist to help facilitators make informed decisions about whether they should use or not use digital tools in outdoor experiential learning (Hills and Thomas, 2020), this research has found that practitioners identified that a lack of knowledge and experience of using digital tools was a barrier to the adoption and use of digital tools. As such without training to address these gaps, this could limit the effectiveness of such existing frameworks. A lack of resources and inadequate training has been found to affect the implementation of virtual fieldwork (Firomumwe, 2022), with training that enhances knowledge, develops skills, and improves access to resources leading to wider uptake and adoption of digital technologies in education (Kolil and Achuthan, 2023; Herrera-Pavo and Ornellas, 2024). The sharing of resources and dissemination via a participatory workshop in this research offers ways to support this implementation and wider adoption of digital tools in fieldwork and could form part of a wider suite of training to address gaps in facilitators fieldwork knowledge, skills and confidence (Woodley *et al*., 2024).

In reflecting upon the UTAUT (Marikyan and Papagiannidis, 2023; Xue *et al*., 2024) the workshop supported participants to identify the usefulness (performance expectancy), recognise the ease of use of the digital tools (effort expectancy), have collaborative discussions and garner peer support (social influence). Human perception of technology can be a barrier to its adoption and integration (Fletcher *et al*., 2007; Welsh *et al*., 2013; Smith and McNeal, 2023). Three digital tools were readily accepted by the fieldwork community. Of these DFNs and VFTs had low existing usage from workshop participants. This is a positive of the participatory workshop as a mode of sharing educational research outputs and digital approaches to fieldwork, as despite existing low-usage, participants had an interest in incorporating them into their own practice post-workshop. It shows value in a workshop model as an investment in training to impact practitioners' perspectives of technology use in fieldwork. The sharing of digital tools, demonstration of delivery approaches and facilitating collaborative discussions supported practitioners to make informed decisions about the adoption of digital tools in fieldwork.

Although participants shared 11 new ideas or adaptations to how the live broadcast approach could be used, there was a hesitancy to adopt live broadcast as a digital fieldwork approach. This delivery approach did not have an off-the-shelf resource that participants could use, and instead shared an example of the approach. This delivery mode uses technology (live broadcasting) that participants had less familiarity with. Live broadcasting is also a novel delivery mechanism with examples of its use limited to fieldwork organisations (Stagg *et al*., 2022) and distance learning institutions (Brown *et al*., 2023). Workshop participants were less able to identify the ease of use of this approach and the approach lacks any substantial social influence to support its adoption (Davis, 1989; Marikyan and Papagiannidis, 2023).

6.5.2 Barriers to adoption of digital technologies in fieldwork

The workshops alleviated some of the negative views and increased the proportion of positive views of digital tools shared by participants. However, barriers to adoption of digital tools remain. These include the time needed to develop approaches to suit individual contexts and a lack of practitioner knowledge in aspects related to technology use e.g. basics of GIS. This is in line with other studies that identified that facilitators invest significant time adapting tools to suit individual needs and learning goals (Foley *et al*., 2024) and those that identified the requirement of training to develop skills and confidence in using digital tools (Fletcher *et al.*, 2007; Welsh *et al.*, 2013; Josua and Kanyemba, 2023; Smith and McNeal, 2023;), where staff time and competence were barriers to adoption. Despite these participatory workshops offering some initial training in these digital approaches, these barriers to adoption, identified in other studies, remain. This indicates that the participatory workshops did not offer sufficient training and that further practitioner training was required. Wider issues, such as work-load pressures, could still mean that practitioners lack the time needed to develop approaches and impact the overall adoption of digital tools.

Interestingly, while other studies have raised concerns about digital fieldwork approaches replacing traditional in-field fieldwork (Boyle *et al*., 2007; Maw *et al*., 2011), this research presents a more nuanced practitioner view on the challenge associated with digital tools in fieldwork. Practitioners in this research recognised the value of both digital and in-field approaches, but that a need to retain balance when using the technology so as not to diminish the outdoor experience was essential. This is more akin to the complementary perspective of digital tools in fieldwork (Thorndycraft *et al*., 2009; Stokes *et al*., 2012; Edwards and Larson, 2020).

6.5.3 Open research practices

The use of participatory workshops was an effective tool to disseminate outputs from education action research, reaching a diverse audience of practitioners, and supports the view that open principles can transform fieldwork (Scerri *et al*.,2020). Although institutional support is encouraged to support technology integration (Panakaje *et al*., 2024), not all departments have access to skills and technology required to develop their own approaches to virtual fieldwork (Guillaume *et al.*, 2023), with these participatory workshops offering a chance to address this issue.

The outputs shared within the participatory workshops were open access digital tools. Three of the tools were able to be used as off-the-shelf resources (DFN, VFT and digital preparation resources) but practitioners also had the option to duplicate and adapt to suit their individual contexts. This access to easily adopted resources as well as the encouraged adaptation was viewed positively by workshop participants and is an example of 'open scholarship' (Veletsianos and Kimmons, 2012; Greenhow and Gleason, 2014). The participatory workshops offered a creative mode of disseminating research outputs to non-HE institutions

(69% of registrations were from non-HE institutions). Sharing of scholarship outside of HE has broad benefits and can help institutions meet outreach and dissemination of knowledge performance indicators (McKiernan, 2017).

In line with challenges found in other research about educators' experience of using open education learning objects such as flexibility, context, and pedagogical expertise (Fulantelli *et al*., 2008; Klebl *et al*., 2010), this workshop addressed this by sharing resources which could be used off the shelf but were also fully customiseable, offered opportunities for discussions on how the tools could be used in a variety of contexts (subjects, phases, supporting individual students) and emphasised purposeful technology use. Although participants had access to all of the open education resources via Padlet during and after the workshop, it would have been advantageous if a portal could have been used to provide a personal and shareable work space (Klebl *et al*., 2010) where participations could continue to share the developments beyond the idea and action planning stage which the workshops offered, with these being used as future sources of inspiration and inform iterative development opportunities (Fulantelli *et al*., 2008)

6.5.4 Collaboration between participants

The participatory workshops supported participants to share new ideas and adaptations to the digital tools demonstrated in the workshop. Inspired by the four approaches, 38 ideas and new applications related to the four approaches were shared by workshop participants. Most research on digital fieldwork tools seek student feedback and/or outcomes on the approaches (Scott *et al*., 2012; Mukherjee, 2019; Dolphin *et al*., 2019; Yeo *et al*., 2020) or facilitator views on the approaches (Stokes *et al*., 2012; Cooke *et al*., 2021; Bacon and Peacock, 2021). This research presents a unique perspective by sharing practitioners' views on how the four digital approaches could be used or adapted to suit their individual contexts. This not only showcases the broader potential of these existing tools, but also value in the method of participatory workshops to disseminate research outputs and foster discussions around adaptation and adoption of these education research outputs, which supported the building of a learner community to support integration of tools (Long *et al*., 2019)

The participatory workshops adopted a range of synchronous and asynchronous communication tools (anonymous Padlet posts, Zoom/Team chat comments, verbal discussion). The collaboration was viewed positively by participants and was one of the most useful aspects of the workshop. This is in contrast to a previous study that found that group belonging, and satisfaction were lacking within online research methods (Davies *et al*., 2020). The use of Padlet likely helped to foster a positive open and atmosphere due to its ease of use and long-term access post-workshop (Naamati-Schneider and Alt, 2023). Implementing a Safer Spaces Agreement within this research helped to manage expectations about the collaboration process (de Nooijer *et al*., 2021) and ensure that the discussion, sharing, and collaboration were one of the most useful aspects of the workshops.

6.6 Limitations and plans for the future

It should be noted that the participants who attended a workshop titled 'Enhancing fieldwork with digital tools' may not represent the broad spectrum of views on this subject area, which limits the reliability of any generalisations discussed within this research.

Participants within this research study completed the post-workshop survey and DAPs either immediately or a few days after attending the workshop. The objectives shared represent a short-term intent to implement the actions arising from the workshop. Therefore, the scale of the intention-action gap (Conner and Norman, 2022; Celik and Cagiltay, 2024) has not been considered within this research. Time and technical issues (Celik and Cagiltay, 2024) have been found to impede action and are particularly relevant to the digital actions within this research as these were identified as specific barriers to adoption post-workshop. Although not within scope of this research, the longer-term impact of the workshop could be evaluated, should a follow-up be conducted in 6-12 months' time which would have the potential to capture actions rather than intentions.

Although the DAPs enabled participants to develop objectives, priorities, and metrics for their development areas post-workshop, they were developed in isolation by a single practitioner. Education operates within a 'complex community of stakeholders' (McCarthy *et al*., 2023), and there would be value in enabling participants to work with colleagues and other stakeholders in their individual settings to develop their digital action plans. It is likely that this would help the adoption to garner more support within their educational settings and increase the likelihood of the adoption.

6.7 Summary

Participatory workshops were used to share four digital fieldwork approaches (DFN, VFTs, digital preparation resources and live broadcasts) with practitioners from HE, school/colleges, and fieldwork organisations. The workshops were a success, with 98% of participants satisfied with the workshop, and all attendees learning something new. A key outcome of the workshop was the digital fieldwork approaches acting as a source of inspiration, with 38 new ideas and/or applications shared by participants. The workshop helped participants to increase knowledge of the digital tools, as well as the purpose of the approaches and how to use them although barriers to the adoption remain including time constraints. Three of the digital tools (DFN, VFT and digital preparation resources) were positively received, with participants keen to adopt and adapt the tools within their own practice. Practitioners were less likely to adopt the live fieldwork broadcasting approach, due to the unfamiliarity of the delivery mode. This research highlights value in the role of adopting open research practices via the sharing of open educational resources in participatory workshops to address both a resource gap and a knowledge and skills gap in practitioners to support technology integration. This acknowledges the need for further training, and the need for collaboration within institutions to support the successful integration of the digital tools in fieldwork. Limitations of this research include the self-selecting method of recruitment for workshop participants and the lack of follow-up with participants post-workshop meaning that the scale of the intention-action gap cannot be determined.

Chapter 7. General discussion

7.1 Introduction

This research's primary objective was to explore the development and integration of digital tools in fieldwork, particularly within the context of biosciences fieldwork in Higher Education (HE). This involved the examination of the current landscape of fieldwork post-Covid-19 within the literature and from practitioners via expert panel interviews and a fieldwork practitioner survey, before working with students to explore the defining characteristics of digital fieldwork and using this in the design of three digital tools. These three digital tools; digital preparation resources, Digital Field Notebook (DFN) and Virtual Field Trips (VFTs) underwent user-testing. The impact of using one of these digital tools during fieldwork, the DFN, was examined with students identifying value in its use, but barriers to its integration remain. The student experience of working in partnership to develop and implement a further digital fieldwork approach, live broadcasting, is explored. The developed tools were shared with the fieldwork community via participatory workshops, with feedback sought on their adoption, adaptation, and integration.

This discussion chapter interprets the key findings of this research in the context of the existing literature and relevant theories such as pedagogic frameworks and technology acceptance models. The significance and implications of the findings will be evaluated, with limitations discussed and directions for future research proposed.

7.2 Key research findings

The initial hypothesis posited that digital tools would enhance fieldwork and could be integrated within HE fieldwork teaching in the biosciences focusing on the following research aims (RAs) throughout chapters 2-6.

- RA1. Define digital fieldwork and use this definition to broaden existing models of fieldwork (Chapter 2).
- RA2. Consider to what extent students can be involved in designing digital tools to address pedagogic challenges and enhance fieldwork (Chapter 3).
- RA3. Explore the impact of working in a partnership with students to deliver fieldwork using live broadcast methods (Chapter 4).
- RA4. Identify the impact of using a digital tool during fieldwork (Chapter 5).

- RA5. Share key findings and guidance within the wider fieldwork community to support the integration of digital tools within fieldwork (Chapter 6).

The key findings of this research highlight several important insights from both students' and practitioners' perspectives, as well as the development and integration of digital tools in fieldwork teaching. Practitioners acknowledged that digital fieldwork offers valuable support, preparation, and specific digital skills. However, while in-field fieldwork was considered essential, opinions on the value of digital fieldwork were mixed. Both in-field and digital fieldwork present unique challenges and opportunities, emphasising that they should not be seen as interchangeable delivery modes but rather as complementary approaches. From the students' perspective, digital fieldwork was recognised for its ability to facilitate skill development, provide immersive experiences, enhance access and equity, and serve as effective preparation for in-field experiences. In reviewing student priorities for digital fieldwork alongside the challenges and opportunities of digital fieldwork identified within expert panel interviews and fieldwork practitioner survey several similarities can be identified. Both groups identified the value and potential for digital fieldwork to enhance digital skills, and for digital fieldwork to support a blended pedagogic approach by providing vital preparation prior to in-field fieldwork. Additionally, both groups also identified the need to consider the technology used carefully, to avoid digital access issues or the requirement of additional training or onboarding to use the digital tools.

Regarding digital tools and their integration, three specific tools (digital preparation resources, DFN, and VFTs) were developed and incorporated into fieldwork teaching. A low-cost solution for live fieldwork broadcasting was also proposed. Alongside students informing the initial development of the tools, continuous feedback during user-testing led to ongoing development and refinement of these digital tools. This shows two approaches of working with students to design digital tools and highlights value in doing so. Feedback from students for three of the digital tools (preparation resources, DFN and VFTs) was categorised into three areas: pedagogy, content, and technology. This categorisation informed improvements to the tools and was used to evidence the Technology, Pedagogy and Content Knowledge (TPACK) framework (Koehler and Mishler, 2005) highlighting the knowledge required for technology integration in education. While students generally found the three digital tools easy to use, their opinions on the future use and integration of these tools within fieldwork varied. This was particularly apparent when the impact of using one of the digital tools (DFN) during fieldwork was assessed. Although students used the DFN to make observations of species, environment, and record ‘good things in nature’, underscoring the significance of observation and landscape interpretation in fostering a connection with nature, uptake for using the DFN during fieldwork was extremely low. Despite working with students to co-design digital fieldwork approaches, it has been difficult to uncover the impact of using a digital tool during fieldwork, due to un-resolved barriers affecting uptake and use of a DFN during biosciences fieldwork.

The placement opportunity, which was the mechanism for working in partnership via the live fieldwork broadcasts were generally positive, offering students new experiences and a supportive group work environment. However, challenges such as uncertainty involved with the live delivery mode and time pressures were also noted. Placement students reported increased competencies in key graduate attributes and identified opportunities for skill development and the acquisition of transferable skills. The live broadcasts also encouraged student decision-making and reinforced the value of partnership working. The future of live broadcasting in fieldwork education was presented via future possible contexts with potential impact areas proposed including equality, diversity, and inclusion (EDI) and sustainability, enhancing the overall fieldwork experience and strengthening the teaching-research nexus.

Dissemination via participatory workshops saw high levels of engagement with practitioners across a range of contexts. These workshops sparked new ideas, particularly related to DFNs. Participants reported increased knowledge of each of the digital tools and expressed high satisfaction post-workshop. The use of open scholarship principles and participatory workshops proved effective in disseminating educational research, fostering collaboration among participants, and increasing participant knowledge on the use of digital tools in fieldwork.

7.3 Novel contributions and alignment with current knowledge

In relation to defining digital fieldwork, this research presents a fieldwork taxonomy that can be used to describe all current fieldwork practice. It offers an update to earlier models that described virtual fieldwork (e.g., Klemm and Tuthill, 2003) by incorporating current and recent developments in the use of digital tools within fieldwork, aligning with the rapid technological adoption accelerated by the Covid-19 pandemic. It is a step towards the consistent and accepted terminology required within fieldwork (Foley *et al*., 2024). Unlike some models within the literature that only describe an example of individual digital fieldwork practice (Geange *et al*., 2021; Nicotra *et al*., 2022) or frameworks that can be used as a decision-making tool for the adoption of digital tools only in fieldwork (France *et al*., 2020; Hills and Thomas, 2020), this model is an encompassing tool that can be used as a single classification system to describe both in-field and digital fieldwork approaches across disciplines. Drawing upon guidance from the literature (France *et al*., 2020) this model defines fieldwork practice in terms of both technology (delivery mode) and pedagogic approach. In addressing some of the challenges associated with a lack of context behind individual case studies of examples of digital fieldwork practice (Adekola *et al*., 2017; Atchison *et al.*, 2019; Houghton *et al*., 2020; Verdes *et al*., 2021; Stagg *et al*., 2022), the inclusion of a rationale (informed by a review of the existing challenges for learners and facilitators) supports the justification of the delivery mechanism and pedagogic approach. This ensures that the 'challenge' experienced can be evidenced by student and facilitator voices, enabling the digital development to meet user needs. The presented fieldwork taxonomy model within this research is non-subject specific, and this research has demonstrated that it can be used with relational classifications of fieldwork planning that focus on building progression in fieldwork experiences (Oost *et al*., 2011; Peasland *et al*., 2019).

Existing literature presents a contested view on the role and value of digital tools in fieldwork within the biosciences and more broadly across other disciplines (Boyle *et al*., 2007; Thorndycraft *et al*., 2009; Maw *et al*., 2011; Stokes *et al*., 2012; Welsh *et al*., 2013; Medzini *et al*., 2015; Smith *et al*., 2016; Edwards and Larson, 2020; Smith and McNeal; 2023). Much of this represents a pre-pandemic view, where those who had direct experience of using digital tools may have been those early adopters of such technology who exhibited self-efficacy and digital literacy as key characteristics that supported the innovative use of technology in fieldwork (Dale *et al*., 2021). While Barton's 2020 post-pandemic study provided information on a broad range of facilitators' experiences of digital fieldwork during this pivot in delivery during Covid-19 delivery, Barton's findings focus on the barriers to remote teaching of fieldwork. This current research provides a post-pandemic analysis of practitioner views on the challenges and opportunities of both in-field and digital fieldwork. Like Barton (2020), it recognised that digital fieldwork was not a direct replacement, with practitioners identifying issues with digital delivery modes.

Despite the mixed views of digital fieldwork from the fieldwork practitioner survey, there was balance between the number of challenges and opportunities shared across both delivery modes, with most of these unique to the delivery mode. Yet, it also recognised associated costs and the realised value of fieldwork as being common issues across both delivery modes, which has not been recognised elsewhere. This research adds to the body of knowledge by providing fresh insights on how fieldwork practices have evolved post-pandemic, and how digital and in-field approaches are defined and viewed by practitioners and students alike. This student voice contribution is often missing or limited within the literature (Tang, 2013; Medzini *et al*., 2015; Welsh *et al*., 2015; Adekola *et al*., 2017; Dolphin *et al*., 2019; Adams *et al*., 2020; Lee *et al*., 2020; Bos *et al*., 2021; Senger and Nordmo, 2021; Xie *et al*., 2021; Rodríguez *et al*., 2022; Wright *et al*., 2023) and is of particular relevance.

While some literature has cited in-field fieldwork as being at risk from digital fieldwork approaches (Boyle *et al*., 2007), presenting an arbitrary choice between the two delivery modes, this research identified the potential for a collaborative approach between digital and in-field approaches. This included the digital preparation resources and how these could be integrated via an emerging model of a blended approach to better meet the needs of learners. Although other blended approaches to fieldwork within the literature showcase how digital and in-field tools can be used in a collaborative manner (Durrant and Hartman, 2015; Geange *et al*., 2021; Nicotra *et al*., 2022; Oktavianto *et al*., 2023) they lack detail on both the roles of learners and facilitators of fieldwork and the management of transitions between the digital and in-field components.

The DFN, another tool co-designed within this research, identified a pathway to manage transitions between digital and in-field components via the use of technology in field, m-fieldwork approaches, and digital dashboards. Although the use of DFNs within the geosciences are well-documented contributing to enhancing the learning experience and improving fieldwork practice (Senger and Nordmo, 2021; Xie *et al*., 2021; Phantuwongraj *et al*., 2021), this research exemplified using a DFN during HE fieldwork in the biosciences, where there is little existing research (Hinze *et a*l., 2023). This current research contributes unique insights into the application of digital tools during fieldwork in the biosciences; for species identification, developing a sense of place and nature connection; expanding the scope of existing geosciences research into DFN use. Despite the recognised utility and useability of the DFN by students, this research uncovered a student hesitancy to use mobile devices during biosciences fieldwork. This hesitancy adds to the complex narrative on mobile device use during fieldwork within the literature where issues of anxiety (Kwet and Prinsloo, 2020) and distraction (Smith *et al*., 2016) have previously been identified. This current research finding of 'hesitancy' is of relevance to digital fieldwork practice that promotes a 'bring your own device' ('BYOD') approach (Welsh *et al*., 2018) as it highlights the very nuanced perceptions that students have related to technology use during fieldwork. This 'hesitancy' is of importance when integrating tools such as the DFN during fieldwork.

In considering the extent to which students can be involved in designing digital tools to address pedagogic challenges and enhance fieldwork, the emerging model of a blended approach to fieldwork within this current research offers a process, which was co-developed with students based on their feedback, for fieldwork facilitators to follow to support the integration of digital tools alongside in-field fieldwork. It was recognised as valuable digital fieldwork practice by the wider fieldwork community attending the participatory workshops and one which supported the integration of digital tools within fieldwork. By providing reflective cycles, this model showcased how digital preparation resources enabled students to move from conceptualisation to experimentation phases when applying the experiential learning cycle (Kolb, 2015) within an integrated fieldwork approach utilising digital tools, extending the existing work of experiential learning cycles in fieldwork (Healey and Jenkins, 2000; Krakowka, 2012; Scott *et al.*, 2012; Burden, 2017) and geography education (McPhee, 2021). With recent increased discussion on EDI in fieldwork and outdoor learning (Beltran *et al*., 2020; Cooke *et al*., 2020; Zavaleta *et al*., 2020), good practice guidance recommends a focus on preparing learners for fieldwork (Yorke *et al*., n.d; Kingsbury *et al*., 2020; Lawrence and Dowey, 2022), yet there are minimal practical examples of what this 'preparation' could entail from the literature, or how this could be incorporated within fieldwork modules. This current research shares detail on the content, pedagogy, and technology to support the use of digital preparation resources within a blended approach to fieldwork in the biosciences. The outputs themselves, of the co-designed digital preparation resources, strongly evidence the extent to which students can be involved in designing digital tools. The digital preparation resources were viewed positively by practitioners during the participatory workshops, and with many participants inspired to adapt and tailor the co-designed tools so that they could readily be used in other disciplines and contexts.

To the best of the author's knowledge this research presents the first student co-produced live fieldwork broadcast in geography, earth, and environmental science (GEES) or biosciences disciplines. It extends the work of the FieldCast team at the Open University (Open University, 2023; Brown *et al*., 2023), by presenting a low-cost, low-tech alternative to live broadcasting, offering a replicable model for other institutions. Students' views captured during the exploration phase of this research were incorporated into the initial design of the three digital tools and student feedback was used to develop the digital tools further during the user-testing phase. The co-production partnership used to develop the live broadcasts presents a more enhanced approach to involving students in the design of digital tools, with the impact of this co-production partnership shared within this research. Although the communication strategies adopted within live fieldwork broadcasts have been researched elsewhere (Brown *et al*., 2023), this current research presents information on the student experience and impact of the partnership essential to the successful co-production of the live fieldwork broadcast extending the notion of the extent to which students can be involved in the design of digital tools in fieldwork.

Live broadcasting in fieldwork is still a relatively novel delivery mechanism to diversify delivery mode of fieldwork (Stagg *et al*., 2022; Open University, 2023). This current research suggests several new areas of application for live fieldwork broadcasts that are all unexplored within the literature, including researcher-led broadcasts and partnerships with overseas organisations. This highlights future potential in addressing cost and sustainability issues of travel to some fieldwork locations (Mauchline *et al*., 2013; Telford *et al*., 2024), improving equality of access to fieldwork (Houghton *et al*., 2020; Yorke *et al*., n.d; Hutchinson *et al*., 2024) and opportunities to bridge the research-teaching gap (Griffiths, 2004; British Academy, 2022).

This research reinforces the identified need for training to address fieldwork facilitators knowledge and skills gaps, which can support the integration of digital tools in fieldwork (Fletcher *et al*., 2007; Welsh *et al*., 2013; Nazarkulova and Strobl, 2023) by showing a desire for targeted professional development on this subject. Uptake from practitioners from a range of backgrounds and experience for registration and attendance at the participatory workshops was observed. Inspired by the value of open-scholarship and the role of 'configurable learning objects' as open-education resources (Klebl *et al*., 2010), this research goes a step further in sharing an effective training method to increase knowledge on the role of digital tools in fieldwork and address those knowledge gaps identified by others (Fletcher *et al*., 2007; Welsh *et al*., 2013). Additionally, the participatory workshops were an effective method to share resources and promote discussion on adoption and adaptation of digital tools in a variety of contexts. They showcased how sharing specific examples of digital tools in fieldwork can inspire practitioners, offering a variety of adaptable uses and demonstrating their versatility in various contexts. This highlights the value and impact of open-scholarship practice, the sharing of digital expertise and open-education resources within a digital fieldwork context. This is valuable to the fieldwork community as not all institutions having the required skills or technology to develop their own approaches (Guillaume *et al*., 2023).

7.4 Limitations of the Research

There a number of methodological limitations present within this research. Although the three digital tools were informed by practitioner and student perspectives shared in Chapter 2, they underwent limited user-testing, with a small number of students from a single HE institution. Despite Chapter 3 identifying that this process was worthwhile (with valuable technology, content and pedagogic developments made) challenges remain for the use and integration of the digital tools that were not overcome through the user-testing. This included students who were still unclear on the purpose of the VFTs and barriers to the use of technology outdoors during fieldwork, which was also evidenced in the low uptake of the DFN use in Chapter 5, despite the recognised usability of the tool. Although students were involved in the design and development of the tools, barriers still outweigh the benefits to their use, ultimately limiting integration of the tools designed to address pedagogic challenges.

The findings within Chapter 6 are all based on practitioners who registered an interest and attended the participatory workshops. Although the workshops were free to attend, delivered online and with several dates offered, participants still had to attend in their own time. While participants had a range of experience with digital tools, those that attended may be those who were already interested in digital tools, or those who had a strong desire for professional development and wish to learn from these innovations. This participant bias may limit the generalisability of findings on the interest in adoption of the digital tools, with those in attendance perhaps the 'early adopters' of these approaches and may not represent the full spectrum of views on digital fieldwork. The effectiveness of the action planning and the outcomes derived from the participatory workshops should also be reviewed. This action planning was time limited, completed in isolation and missing valuable collaborative institutional development to support integration. The action plans only indicate intention rather than action and the scale of this intention-action gap (Conner and Norman, 2022; Celik and Cagiltay, 2024) has not been quantified within this research. Most participants wrote short-term objectives, with a methodological limitation of no follow-up to measure action, progress, or impact.

The low-cost, low-technology solution and the co-production partnership developed to deliver the live fieldwork broadcast, is only a proof of concept, limited to a single UK HE institution with low audience numbers. Although there were a number of ideas shared within the participatory workshops that showed that the live broadcast inspired participants, live broadcasting did not appear in any of the participants digital action plans. Unlike the other three digital tools shared, participants had a reluctance to adopt this practice. This limits the generalisability of the live fieldwork broadcast approach to other contexts and could affect the testing of the future possibilities shared within this research.

7.5 Proposed future research directions

Despite useability and utility there are remaining barriers identified within this research that students face when using the digital tools during fieldwork. Beyond just identifying these barriers, more research is needed to, wherever possible, minimise and/or remove these identified barriers to support the successful integration of digital tools in fieldwork. Ideally this should start by working with a larger and more diverse student group in a second phase of user-testing of the three digital tools developed within this research. Additionally switching the focus of the student collaboration from design/development (as in the research within Chapters 2, 3 and 4) to working with students on integrating these tools should be considered. This may involve research into improving the digital literacy of students which may increase confidence to use the tools, enhancing ownership and alignment of the digital tools with their needs.

In supporting students to identify the purpose of a digital tool, recognise the associated value and acknowledge that these potential benefits outweigh any associated barriers or hesitancy, further research is needed to identify the impact of using specific digital tools on student outcomes. Although logistically challenging and with some ethical considerations, such work that may consist of longitudinal studies and/or randomised control trials would be beneficial (White, 2013; Styles and Torgeson, 2018). This impact evaluation with a large and diverse sample of students, modules and universities should include the collection of baseline data (fieldwork performance and engagement) pre-intervention, before assigning participants randomly to either the intervention group which would use the digital tool, and a control group which does not. The intervention group would have the digital tool integrated within their fieldwork. Throughout the course of the intervention, assessment and observations would be undertaken, with comparative analysis and trends tracked. Outcome reporting from this research would support data on the efficacy of the tool and provide detail on the impact of fieldwork outcomes with the identified policy and practice implications supporting more mainstream adoption of the digital tools by facilitators from a variety of contexts (White, 2013).

To better understand and begin to quantify the intention-action gap for facilitators integrating digital tools in fieldwork, future research should look to complete follow-ups with participants of the workshops to evaluate the long-term impact of workshops on practitioner practices and illustrate the decision-making process undertaken which could be exemplify existing frameworks on digital tool adoption (France *et al*., 2020; Hills and Thomas, 2020). Recognising that transitions and adoption of digital technologies are disruptive, with technology changes exponential and organisational change logarithmic (Martec's Law) (Brinker and McCellan, 2014; Brinker, 2016; 2020). There would be value in uncovering progress towards actions identified within practitioners' digital action plans, any changes to practice based on outcomes from the workshops and any barriers that may have prevented progress. Drawing inspiration from the effective role of a professional learning community to bridge this intention-action gap (Long *et al*., 2021), ongoing collaboration and peer support could be fostered by the creation of an online portal (Klebl *et al*., 2010). Inspired by the role of early adopters to drive digital literacy improvement (Kimberley and Suvandzhieva, 2021), case studies could be developed and used to inspire and guide others in the fieldwork community to adoption of the technology innovation (Fulantelli *et al*., 2008). Additionally, practitioners who have directly adopted digital tools without modification should be given the opportunity to participate in the impact evaluation. This will aid in selecting participants for longitudinal studies involving randomised controlled trials across multiple institutions.

Using both the schematics and required technology to network the field environment and the logistics of running a student placement, the proof-of-concept study of a student co-produced live fieldwork broadcast should be replicated in other academic settings to add to the small evidence base on live fieldwork broadcasting within the literature (Stagg *et al*., 2022; Brown *et al*., 2023; Open University, 2023). This replication should involve rigorous pre- and post-testing of skills, rather than relying on self-reported skill development as in this current research. It should also enable, encourage, and capture these other institutions experiences of adopting, adapting and evaluating this live broadcast approach to fieldwork via a process evaluation. Additionally, Chapter 4 outlined several other potential applications of live fieldwork broadcasts that remain untested. Future broadcasts should aim to test the feasibility and impact of for example:

- Connecting overseas research institutions with HE institutions.
- Linking postgraduate researchers in the field with undergraduates.
- Facilitating connections between students conducting fieldwork in multiple locations.

However, before further developing these live fieldwork broadcasts, future research should focus on methods to increase viewer numbers and engagement. Due to the novelty of live broadcasting in fieldwork, this may require looking towards other applications of live streaming or broadcasting and live interactive polling for inspiration on appropriate approaches (Wang and Li, 2020; Lv *et al*., 2022) and investigating the suitability of these methods within the live fieldwork broadcast content. This would help to better understand the viewer experience and identify ways to improve the live broadcasts.

7.6 Summary and implications for practice

This research presents a fieldwork taxonomy to define the broadened practice we see within fieldwork across the biosciences and GEES disciplines. Developed from a review of the literature, expert panel interviews and practitioner surveys this tool uses pedagogic approach, delivery mechanism and an underpinning rationale this comprehensive tool can be used by facilitators to define and plan their fieldwork practice. The digital preparation resources, DFN and VFTs are three outputs of this research that are available to the fieldwork education community as open education resources. These have been co-developed with students and refined based on student feedback. This research highlights value in using the 'Students as Partners' approach to co-design digital fieldwork and provides useful insight to support the integration of these digital tools in fieldwork. The live fieldwork broadcast approach adopted within this research reveals the potential to enhance fieldwork practice without technology and cost restraints via this novel delivery mechanism. This approach has identified potential to address EDI, sustainability challenges in fieldwork and enhance the research-teaching nexus. Participating in the co-production partnership was beneficial and enjoyable for students, offering authentic opportunities for decision-making and experience of working in a collaborative team environment. Disseminating insights from this research via participatory workshops successfully fostered the development of innovative ideas through collaboration and discussion and highlights value of the three developed tools (digital preparation resources, VFTs, DFN) and the two developed approaches (live fieldwork broadcasts and blended approach to fieldwork) beyond the biosciences in HE. Importantly the participatory workshops provide a mechanism to address knowledge and skills gaps within the fieldwork education community through practitioner engagement and knowledge-sharing opportunities.

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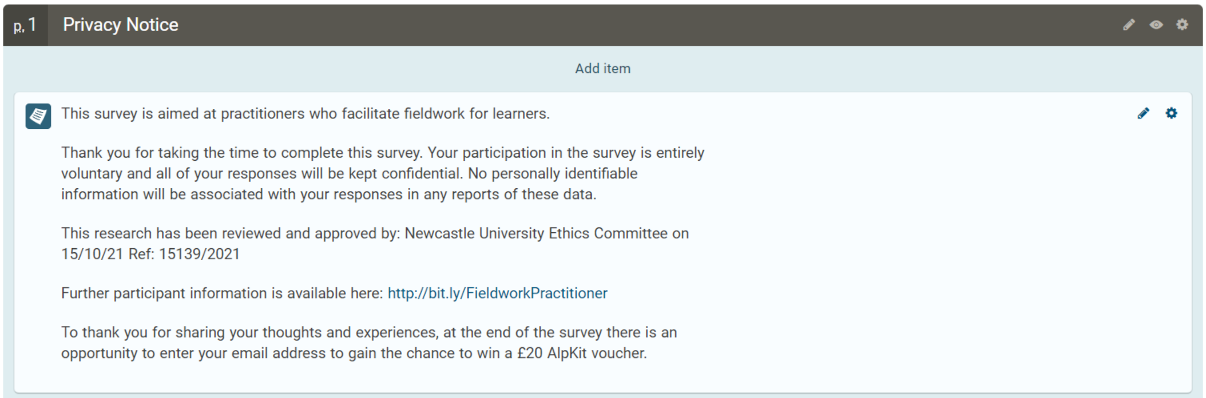
Appendices

Appendix 2.1 Expert panel interview schedule

- Share your background in fieldwork and your experience in digital fieldwork approaches.
- What is the purpose of fieldwork?
- What are the main challenges and opportunities of fieldwork?
- What is the purpose of digital fieldwork approaches?
- What are the main challenges and opportunities of digital fieldwork approaches?
- What are the defining characteristics of digital fieldwork approaches?
- What role does digital fieldwork approaches play in enhancing existing fieldwork provision?
- What is needed to support digital fieldwork adoption?

Appendix 2.2 Fieldwork practitioner survey



p. 1 Privacy Notice

Add item

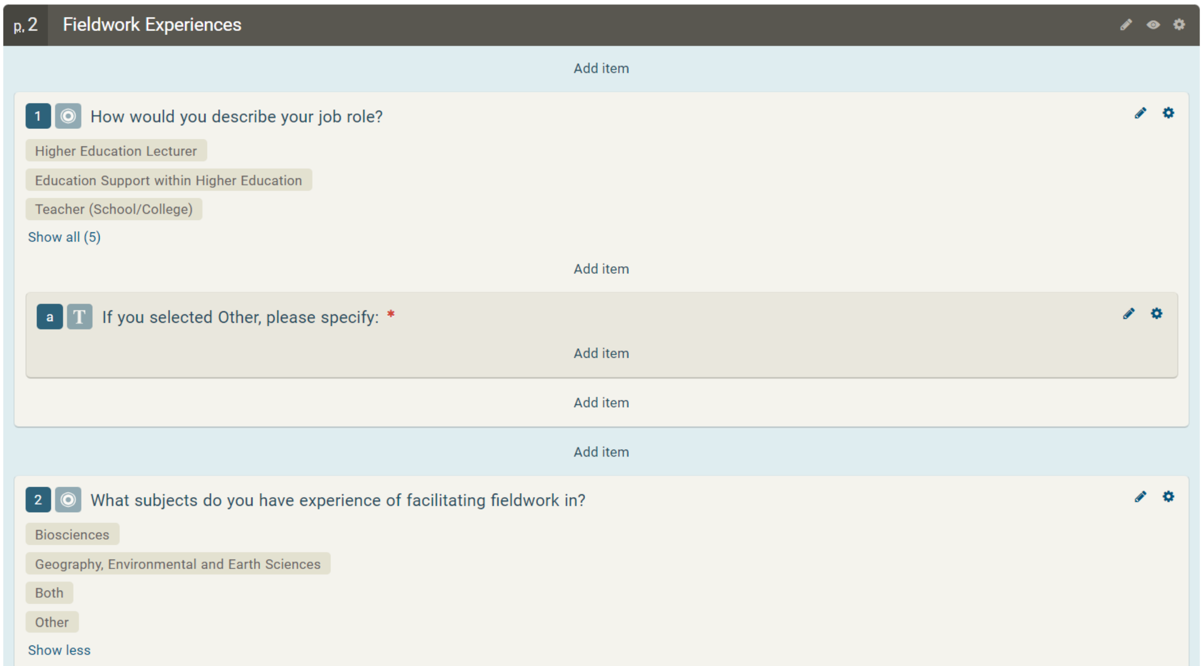
This survey is aimed at practitioners who facilitate fieldwork for learners.

Thank you for taking the time to complete this survey. Your participation in the survey is entirely voluntary and all of your responses will be kept confidential. No personally identifiable information will be associated with your responses in any reports of these data.

This research has been reviewed and approved by: Newcastle University Ethics Committee on 15/10/21 Ref: 15139/2021

Further participant information is available here: http://bit.ly/FieldworkPractitioner

To thank you for sharing your thoughts and experiences, at the end of the survey there is an opportunity to enter your email address to gain the chance to win a £20 AlpKit voucher.



p. 2 Fieldwork Experiences

Add item

1 How would you describe your job role?

Higher Education Lecturer

Education Support within Higher Education

Teacher (School/College)

Show all (5)

Add item

a If you selected Other, please specify: *

Add item

Add item

Add item

2 What subjects do you have experience of facilitating fieldwork in?

Biosciences

Geography, Environmental and Earth Sciences

Both

Other

Show less

3 I have facilitated fieldwork experiences which are:

	Yes	No
On-campus	○	○
Local half-day or full-day trips	○	○
Residential	○	○
Overseas	○	○
Digital or Virtual	○	○
Enhanced by using technology in the field	○	○
Staff-led fieldwork enquiry	○	○
Student-led fieldwork enquiry	○	○
Staff-led fieldwork observation	○	○
Student-led fieldwork observation	○	○
Co-designed with learners	○	○

+ Add question column

Add item

p. 3 In-person fieldwork

Add item

This section will ask you to evaluate your experiences of in-person fieldwork.

Add item

4 Evaluating the in-person fieldwork experiences you facilitate

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I am satisfied with the in-person fieldwork opportunities I provide.	○	○	○	○	○
I am confident in facilitating in-person fieldwork.	○	○	○	○	○
The in-person fieldwork opportunities help to reinforce the taught curriculum.	○	○	○	○	○
The in-person fieldwork provides opportunities for students to acquire subject specific, technical and transferable skills.	○	○	○	○	○
In-person fieldwork is valued by the learners.	○	○	○	○	○
In-person fieldwork is necessary to the teaching of my subject.	○	○	○	○	○

+ Add question column

5 What do you think is the purpose of in-person fieldwork? Please select as many as apply.

- Conduct fieldwork enquiry/implement research design.
- Develop practical fieldwork skills.
- Awe and wonder.
- Promote positive mental health and wellbeing outcomes.
- Learning by doing/first-hand, experiential learning in the real world.
- Signature learning tool to my subject.
- Developing a a connection to nature and pro-environmental behaviours.
- Develop broad knowledge and understanding in a wider context.
- Preparation for employment.
- Other

Show less

Add item

a If you selected Other, please specify: *

Add item

Add item

6 What are some of the pedagogic challenges that students face during in-person fieldwork?

Add item

Add item

7 What do you think are some of the under-utilised opportunities of in-person fieldwork?

Add item

Add item

p. 4 Digital or virtual fieldwork

Jump

Add item

This section will ask you to evaluate your experiences of digital or virtual fieldwork.

Add item

8 Evaluating the digital or virtual experiences you facilitate.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
I am satisfied with the digital/virtual fieldwork opportunities I provide.	○	○	○	○	○	
I am confident in facilitating digital/virtual fieldwork.	○	○	○	○	○	
The digital/virtual fieldwork opportunities help to reinforce the taught curriculum.	○	○	○	○	○	+ Add question column
The digital/virtual fieldwork provides opportunities for students to acquire subject specific, technical and transferable skills.	○	○	○	○	○	
Digital/virtual fieldwork is valued by the learners.	○	○	○	○	○	
Digital/virtual fieldwork is necessary to the teaching of my subject.	○	○	○	○	○	

9 What do you think is the purpose of digital or virtual fieldwork?

- Provide spatial and temporal considerations.
- Promote efficiencies (cost & time) in fieldwork.
- Reduce health and safety and logistical considerations.
- Increase access and equity to fieldwork and fieldwork sites.
- Develop subject specific digital skills.
- Preparation: build confidence and familiarity with locations and fieldwork tasks.
- Wrap-around support: embed classroom/lecture learning with the field.
- Opportunities to simulate scenarios and model variables.
- Interpretation of a variety of data sources.
- Other

Show less

Add item

a If you selected Other, please specify: *

Add item

Add item

10 What are some of the pedagogic challenges that students face in digital or virtual fieldwork?

Add item

Add item

11 What do you think are some of the under-utilised opportunities of digital or virtual fieldwork?

Add item

Add item

12 Are you in support of adopting digital or virtual fieldwork opportunities to enhance existing fieldwork provision?

- Yes
- No
- Unsure

Add item

a Please tell us why.

Add item

Add item

13 In what ways can you be supported to adopt digital or virtual fieldwork opportunities to enhance your existing fieldwork provision?

Add item

Add item

p. 5 Additional comments

Add item

14 Please share any additional comments on your views of fieldwork, the value of fieldwork and other ideas to enhance existing fieldwork provision.

Add item

Add item

Appendix 2.3 Student focus group schedule

Consent & Logistics

- Thank participant for attending the focus group.
- Focus group will be recorded, notes will be taken and we will share outcomes visually during the focus group on the whiteboard.
- Confirm participant agreement for this including transcript.
- Check that participant consent form has been signed.
- Focus group should last 2 hours with scheduled breaks- share schedule with participants.
- Ask if participant has any questions before beginning the interview.

Introduce the research- purpose and how information from the focus group will be used.

This research aims to define and classify digital fieldwork approaches and the role they can play in addressing pedagogic challenges within fieldwork and enhancing fieldwork provision within the Biosciences in Higher Education.

The focus group sits within the stakeholder analysis and aims to address the following research question- *How is fieldwork viewed and valued by different stakeholders?*

Data from these focus groups will inform the construction of a wider consultation which will be promoted through fieldwork, ecology and teaching and learning networks. Analysis from this will inform the design stage of the research project where digital fieldwork approaches will be developed which will aim to enhance current fieldwork provision within ecology modules at Newcastle University by addressing identified pedagogic challenges.

Clarify terms

- In-field Fieldwork: traditional fieldwork approach.
- Digital Fieldwork: Activities that use a simulated or authentic digital environment to present fieldwork activities.
- Blended fieldwork: Combination of in-field and digital fieldwork components.

<table>
<tr><th>NFGT Stage</th><th>Content</th><th>Procedure</th></tr>
<tr><td>Individual Reflection 1</td><td rowspan="2">Q1: What are the defining characteristics of digital fieldwork and how do these enhance existing in-field fieldwork provision?</td><td>Time to record or think about as many ideas as possible in silence, in response to Q1.</td></tr>
<tr><td>Round Robin Sharing of Individual Reflection 1</td><td>Each participant presents one idea at a time and ideas are recorded for everyone to see.
Continues until no new ideas.</td></tr>
<tr><td>Group Discussion</td><td>Q2: Challenges & Opportunities of in-field fieldwork.
Q3: Challenges & Opportunities of digital fieldwork.</td><td>Facilitated open focus group discussion in response to Q2 & Q3.</td></tr>
<tr><td>Individual Reflection 2</td><td rowspan="2">Q1: What are the defining characteristics of digital fieldwork and how do these enhance existing in-field fieldwork provision?</td><td>Revisit of Q1 with time to record or think about any additional ideas in silence, in response to Q1.</td></tr>
<tr><td>Round Robin Sharing of Individual Reflection 2</td><td>Each participant presents any additional ideas. Ideas are recorded for everyone to see.</td></tr>
</table>

BREAK		
Clarify and Classify	Anticipated probes -Would any of these ideas benefit from further clarification? -Do any of these ideas warrant any further discussion? -Can we begin to group some of these ideas together which are similar?	Opportunity to clarify and elaborate on ideas. Recorded items are checked for duplication and responses grouped. Final list of ideas recorded.
Ranking	Please can you vote on your ranked top 5 priorities of characteristics of virtual fieldwork which enhance existing fieldwork provision.	Participants select and rank their top 5 preferences. Tot
BREAK- Facilitator to total up scores Rank 1 = 5 points Rank 2 = 4 points Rank 3 = 3 points Rank 4 = 2 points Rank 5 = 1 point		
Discussion of Outcomes	Here are your ranked outcomes. Is anyone's view not represented in this list? Does anyone disagree with this list, and if so why? Why are these important? What impact would these have on fieldwork outcomes?	Total scores presented and discussed.

Note: If NFGT is taking place online the use of the following Google Jamboard will support the NFGT process whilst using Zoom. Share link with participants.

What happens next?

- Thank for taking part.
- Continuing with other focus groups
- Working on transcribing the discussion parts of the focus group.
- Emergent Coding
- These themes and the resulting priorities will be used to construct a survey promoted through fieldwork, ecology and teaching and learning networks for wider consultation.
- Stakeholder and participant voice can be used to inform the design phase of the fieldwork approaches.
- Do you have any questions for me?

Appendix 3.1 Process evaluation student focus group/semi-structured interview schedules

Digital Field Notebook (DFN)

Consent & Logistics

- Thank participant for attending the focus group.

- Focus group will be recorded, notes will be taken.
- Confirm participant agreement for this including transcript.
- Check that participant consent form has been signed.
- Focus group should last 1 hour
- Ask if participant has any questions before beginning the interview.

Introduce the research- purpose and how information from the focus group will be used.

This research aims to trial the use of digital tools such as using technology in the field to address some of the challenges that learners face in conducting fieldwork within their studies.

The digital intervention has been designed to address these specific challenges and will go through two stages of evaluation. The first is a small-scale 'pilot' evaluation which will consider the process behind the adoption and use of the technology. It will value student voice in this testing phase, to uncover their views and experiences of using the digital approaches, and aim to capture ideas that the users of the approach have to improve it.

This is the pilot or process evaluation. Data from this evaluation will be used to make changes to the digital approach before a final larger scale impact evaluation which will aim to consider the impact of the technology intervention in addressing the underlying challenge experienced.

Clarify terms and digital fieldwork approach used:

- Technology in the field- Use of app on mobile device to collect and collate geo-located qualitative information.

Challenge(s) aiming to address:

- Connections between the field and subject content are often weak with missed opportunities to explore synoptic real-world content and understand the significance of a fieldwork task.

Topic Schedule based on the 'funneling' approach

Stage	Question	Prompts
1: Introductory	Tell me about your fieldwork experiences today.	
2: General information	During fieldwork how would you know learning is taking place and how would you normally capture the learning that was taking place? In what ways have you previously explored the wider significance of completing a fieldwork task?	If you use a field notebook what types of things do you record? If you use a mobile device during fieldwork what types of things do you record?
3: Awareness, attitudes, behaviours	Were any of the questions more or less useful in supporting you to connect the fieldwork to the wider significance of the task? Were any aspects of the app more or less useful in supporting you to connect the fieldwork to the wider significance of the task?	How did you find the: - Reflection questions - Nature connection questions - Field Notebook section - Interpreting the environment questions.

		Which aspects of the app/questions did you utilise most and why?
4: Attitudes specific to targeted objective. Suggestions for improvement	How could your experience of using the technology in the field (app and device) be improved? How could the questions used within the app better support you in exploring the wider significance of a fieldwork task? Is there anything missing? Or anything that didn't need to be included? How might you use the app again in the future?	Did you experience any barriers in using the app? Do you have any suggestion on how these might be overcome? Did you experience any barriers in understanding and responding to any of the questions? Do you have any suggestions on how these might be overcome?
5. Close	Do you have any further questions or comments on the use of the app or questions?	

What happens next?

- Thank for taking part.
- Continuing with other focus groups
- Working on transcribing the discussion from todays focus group.
- Combine data from the Survey, the Focus Group Data and my own field observations to evaluate the use of this digital tool and develop it further based on user feedback.

Test it with larger group to consider the impact of the digital approach in supporting learners to explore the synoptic real-world learning in fieldwork.

Digital preparation resources

Consent & Logistics

- Thank participant for attending the focus group.
- Focus group will be recorded, notes will be taken.
- Confirm participant agreement for this including transcript.
- Check that participant consent form has been signed.
- Focus group should last 1 hour
- Ask if participant has any questions before beginning the interview.

Introduce the research- purpose and how information from the focus group will be used.

This research aims to trial the use of digital tools such as using digital preparation resources prior to fieldwork to address some of the challenges that learners face in conducting fieldwork within their studies.

The digital intervention has been designed to address these specific challenges and will go through two stages of evaluation. The first is a small-scale 'pilot' evaluation which will consider the process behind the adoption and use of the digital approach. It will value student voice in this testing phase, to uncover their views and experiences of using the digital approaches and aim to capture ideas that the users of the approach have to improve it. This is the pilot or process evaluation. Data from this evaluation will be used to make changes to the digital approach before a final larger scale impact evaluation which will aim to consider the impact of the technology intervention in addressing the underlying challenge experienced.

Clarify terms and digital fieldwork approach used:

- Blended- Use digital preparation resources prior to residential fieldwork experiences.

Challenge(s) aiming to address:

- The field can be a novel environment for many learners. Learners have not always had previous positive experiences of fieldwork. These digital resources aim to better prepare students prior to embarking in in-person fieldwork, to increase confidence and readiness to participate and learn in the field.

Topic Schedule based on the 'funneling' approach

Stage	Question	Prompts
1: Introductory	Tell me about your fieldwork experiences today.	
2: General information	Prior to residential fieldwork what do you to prepare for the trip? Prior to residential fieldwork what do the academic staff do to prepare you for the trip? In what ways previously have you used or seen authentic secondary data or authentic voice in fieldwork?	How effective are these? How prepared are you for fieldwork? What impact do these have on the outcomes of the fieldwork experience?
3: Awareness, attitudes, behaviours	Are there aspects of the fieldwork environment which are novel or new to you? What are they? Were any of the StoryMaps or StoryMap content more or less useful in preparation for residential fieldwork? How did you find using the data and the GIS within the StoryMaps? How did you find the videos and 360 images within the StoryMaps?	What impact does this unfamiliarity have on your learning? How confident are you working in the field? How did you use these preparation resources? Which StoryMaps did you use and why?
4: Attitudes specific to targeted objective. Suggestions for improvement	How could the content used within the StoryMaps better prepare you for residential fieldwork? How could your experience of using the preparation resources be improved? Is there anything missing? Or anything that didn't need to be included?	Did you experience any barriers in using the StoryMaps? Do you have any suggestions to how these might be overcome?

5. Close	Do you have any further questions or comments on the digital preparation resources?	

What happens next?

- Thank for taking part.
- Continuing with other focus groups
- Working on transcribing the discussion from todays focus group.
- Combine data from the Survey, the Focus Group Data and my own field observations to evaluate the use of this digital tool and develop it further based on user feedback.
- Test it with larger group to consider the impact of the digital approach in building confidence and better rearing learners prior to fieldwork.

Virtual Field Trips (VFTs)

Consent & Logistics

- Thank participant for attending the focus group.
- Focus group will be recorded, notes will be taken.
- Confirm participant agreement for this including transcript.
- Check that participant consent form has been signed.
- Focus group should last around between 60 and 90 minutes.
- Ask if participant has any questions before beginning the interview.

Introduce the research- purpose and how information from the focus group will be used.

This research aims to trial the use of digital tools such as using virtual asynchronous fieldwork resources to address some of the challenges that learners face in conducting fieldwork within their studies. The digital intervention has been designed to address these specific challenges and will go through two stages of evaluation. The first is a small-scale 'pilot' evaluation which will consider the process behind the adoption and use of the digital approach. It will value student voice in this testing phase, to uncover their views and experiences of using the digital approaches and aim to capture ideas that the users of the approach have to improve it. This is the pilot or process evaluation. Data from this evaluation will be used to make changes to the digital approach before a final larger scale impact evaluation which will aim to consider the impact of the technology intervention in addressing the underlying challenge experienced.

Clarify terms and digital fieldwork approach used:

- Virtual asynchronous- Digital resources that can be accessed and used at a time chosen and suitable by the learner via self-paced instruction.
- Pace- more than just the speed of the learning event it refers to the learning momentum and how well this matches the learners' abilities.
- Progress/progression- learners grasp of essential knowledge and skills.
- Spatial comparisons/considerations- fieldwork environments that are similar in their habitat or ecosystem but are from different locations.

Challenge(s) aiming to address:

- The pace of fieldwork is often set by logistical factors and not by the individual progression of learners participating. Learners often have a one-chance opportunity to develop particular fieldwork knowledge and skills, leading to the potential for fieldwork to become a high-stakes learning event. These asynchronous digital resources aim to provide learners with opportunities to develop fieldwork knowledge and skills in a delivery mode where pace and progressions is learner led. With learners having opportunities to pause, reflect and revisit content where needed.

Stage	Question	Prompts
1: Introductory	Tell me about your fieldwork experiences so far within your studies at Newcastle University.	
2: General information	In your fieldwork experiences so far can you comment on the pace of these experiences? Can you comment on your progression during these fieldwork experiences you have participated in so far? During your previous fieldwork experiences how have facilitators considered pace in their delivery of fieldwork? During your previous fieldwork experiences how have facilitators of fieldwork supported your progression throughout the fieldwork. In what ways previously have you used or seen spatial considerations used within fieldwork?	What impact does the pace of fieldwork delivery have on your learning of fieldwork knowledge and skills? What did you do to support your progression before/during/after the fieldwork? Did this have an impact? What was it? How effective were these? Why were these spatial considerations used? Was there any impact of using spatial considerations.?
3: Awareness, attitudes, behaviours	Can you comment on the pace of these digital resources? Did the resources support your progression? Were any of the StoryMaps or StoryMap content more or less useful in supporting your progression? How did you find using the secondary data and the GIS tasks within the StoryMaps? How did you find the videos and 360 images used within the StoryMaps? What impact did the spatial comparisons within the resources have on your learning?	How did you find the asynchronous self-paced instruction? Did the resources support your understanding of fieldwork knowledge and skills? How did you use these digital fieldwork resources? Would you consider using these resources or similar resources in the future? If so, how would you see using these resources or similar resources in the future?
4: Attitudes specific to targeted objective. Suggestions for improvement	How could the pace of digital resources be better matched to your abilities? How could the digital resources used better support your progression as you developed fieldwork knowledge and skills.	Did you experience any barriers in using the digital resources? Do you have any suggestions to how these might be overcome?

	How could your experience of using the virtual fieldwork experience be improved? Is there anything missing? Or anything that didn't need to be included?	
5. Close	Do you have any further questions or comments on the asynchronous fieldwork resources.	

What happens next?

- Thank for taking part.
- Working on transcribing the discussion from today's focus group.
- Combine data from the Survey, the Focus Group Data to evaluate the use of this digital tool and develop it further based on user feedback.
- Test it with larger group to consider the impact of the digital approach in supporting learners' pace and progress during fieldwork.

Appendix 3.2 Process evaluation student survey

Digital Field Notebook (DFN)

Process Evaluation (PE) Student Test
Student Anon. Code

Technology in field- ArcGIS Survey123

Newcastle University

Stage of study	
Subject of study	
App used	
Device used to access	

Thank you for testing the ArcGIS Survey123 app to collect digital fieldwork notes and your fieldwork reflections. Your time is appreciated in trialing this digital fieldwork approach and in your subsequent considerations on the use of the app.

Valuing student voice is an integral part of this piece of research and the feedback that you provide in this survey and the focus group will be used to further develop this approach for use within fieldwork teaching.

1. Ease of use

	Very difficult	Difficult	Neutral	Easy	Very easy
a. Using the app was...					
b. Using the device in the field was...					

2. What do you think is the purpose of using the app and the associated questions during fieldwork?

3. Assessing the usefulness of the supporting questions in the app

Supporting questions in app	Most useful aspects	Least useful aspects
Landscape Interpretation		
Nature Connections		
Personal Reflections		
Field Notebook		

4. What challenges have you experienced whilst using the app and the supporting questions?

5. What did you like about using the app and the supporting questions?

6a. Has the app and supporting questions enabled you to develop any skills?	Yes	No	Unsure
6b. What skills have you had the opportunity to develop whilst using the app and supporting questions?			

7. What other ways would you like to see this app being used during fieldwork?

8. What suggestions do you have for improving the app?

9. What suggestions do you have for improving the questions used within the app?

	Extremely unlikely	Unlikely	Neutral	Likely	Extremely likely
10. How likely are you to use this app again?					

11. Please share any other comments:

Digital preparation resources

Process Evaluation (PE) Student Test
Student Anon. Code

Newcastle University

Blended- StoryMap Resources

Stage of study	
Subject of study	
Device used to access	

Thank you for testing the ArcGIS StoryMaps as digital preparation for your residential fieldwork. Your time is appreciated in trialing this digital fieldwork approach and in your subsequent considerations on the use of the resources.

Valuing student voice is an integral part of this piece of research and the feedback that you provide in this survey and the focus group will be used to further develop this approach for use within fieldwork teaching.

1. Ease of use

	Very difficult	Difficult	Neutral	Easy	Very easy
a. Using the StoryMaps was…					

2. What do you think is the purpose of using the StoryMap resources prior to residential fieldwork?

3. What challenges have you experienced whilst using the StoryMaps?

4. What did you like about using the StoryMaps?

	Yes	No	Unsure
5a. Have the StoryMaps and the associated tasks enabled you to develop any skills?			
5b. What skills have you had the opportunity to develop whilst using these resources?			

	Extremely unlikely	Unlikely	Neutral	Likely	Extremely likely
6a. How likely are you to recommend these resources to other students.					
6b. How likely are you to use these resources again.					

7. Assessing the usefulness of the StoryMap resources

StoryMap	Did you use it?		Most useful aspects	Least useful aspects
	Yes	No		
Healthy & Safety				
Nature Connectedness				
The Role of Desk Studies				
Residential Fieldwork Experience				
Why fieldwork?				
Kit & Equipment				
Ethics of field research				
Fieldwork Outcomes				

8. What suggestions do you have for improving these resources?

9. What else would you like to see included in these resources?:

10. Please share any other comments:

Virtual Field Trips (VFTs)

Newcastle University

Virtual Asynchronous- StoryMap Fieldwork Resources

Stage of study	
Subject of study	
Device used to access	

Thank you for testing the ArcGIS StoryMap resources as a virtual asynchronous fieldwork environment. Your time is appreciated in trialing this digital fieldwork approach and in your subsequent considerations on the use of the resources.

Valuing student voice is an integral part of this piece of research and the feedback that you provide in this survey and the focus group will be used to further develop this approach for use within fieldwork teaching.

1. Ease of use

	Very difficult	Difficult	Neutral	Easy	Very easy
a. Using the StoryMaps was…					

2. What do you think is the purpose of using the fieldwork resources as a virtual asynchronous fieldwork opportunity?
3. What challenges have you experienced whilst using the fieldwork resources?

4. What did you like about using the fieldwork resources?

	Yes	No	Unsure
5a. Have the resources and the associated tasks enabled you to develop any skills?			
5b. What skills have you had the opportunity to develop whilst using these resources?			

	Extremely unlikely	Unlikely	Neutral	Likely	Extremely likely
6a. How likely are you to recommend these resources to other students.					
6b. How likely are you to use these resources again.					

Appendix 4.1 Student placement semi-structured interview schedules

Interview 1- Pre-placement

Recording and data collection for research project

During this placement you are invited to take part in a research study. You have been provided with a Participant Information Sheet. Please read this information carefully and discuss it with others if you wish. Take time to decide whether or not you wish to take part. If you do decide to take part, you will be asked to sign a consent form. However, you are free to withdraw at any time, without giving any reason and without any penalty or loss of benefits.

This research aims to trial the use of digital tools such as using live broadcast to address some of the challenges that learners face in conducting fieldwork within their studies. The digital intervention has been designed to address these specific challenges and will go through two evaluations. One evaluation is a process evaluation which will consider the process behind the co-production of the live broadcast, to uncover their views and experiences of participating in the co-production of the live broadcast. The impact evaluation will aim to consider the impact of the technology intervention in addressing the underlying challenge experienced and will be targeted at viewers of the live broadcast.

Consent & Logistics

- Thank participant for attending the interview.
- For the purpose of the interview and data collection for the evaluation the interview will be recorded and notes will be taken.
- Confirm participant agreement for inclusion within research project and recording.
- Check that participant consent form has been signed.
- Interview should last 45 minutes-1 hour
- Ask if participant has any questions before beginning the interview.

Overview of the proposed placement

The aim of the placement is to design, develop and deliver a Fieldwork Live Broadcast with

placement students working in partnership with a PhD researcher to co-design the content of the live broadcast and deliver the final live broadcast to its intended audience.

Successful placement students will perform one of three roles during the live broadcast:

1. Live producer & live chat
2. Primary presenter
3. Secondary presenter & live chat

The live broadcast is aimed at 1st year Bioscience students within Newcastle University, with the potential for wider participation. Working with myself, a PhD researcher with experience in Education Development and Live Broadcast, alongside experts from this field from other organisations.

Introduction & placement overview

1. Thanks for sending through your video, did you enjoy anything in particular about making the video?
2. Why are you interested in this particular placement opportunity?
3. Do you have any aims or objectives for this placement?

Strengths & skill development

4. What personal strengths that you possess will you draw upon during this placement?
5. What skills do you think you will use and develop during the co-production of the live broadcast?

Live broadcast

6. What do you think are some of the factors that would make the live broadcast a success?
7. Do you have any ideas for themes or content for the live broadcast?

Questions for us

8. Finally, is there anything you'd like to ask us?

Interview 2 and 3 (Week 3 and week 7 of the placement)

Consent & Logistics

- Thank participant for attending 1:1
- 1:1 will be recorded; notes will be taken.

- Confirm participant agreement for this including transcript remind of consent form.
- 1:1 is scheduled to last for an hour.

1. How is life outside of university?
2. How are you finding managing the placement alongside your studies and other commitments?
3. Tell me about the objectives you have set for the placement.
   Why did you choose them?
   What are you going to do to achieve those?
   What can I do to help you achieve those?
4. What are you looking forward to or enjoying so far in the placement?
5. Do you have any challenges so far in the placement, or any future concerns?
6. Have you used or developed any skills so far during the placement.
7. Using the ladder of student participation, how would you define the partnership of the placement?
8. How do you feel the co-production process is going so far?
   Would you like more or less direction from me?
9. How do you find working with the team?
   Do you have any suggestions for improvement in the way we work together?
10. Can I answer any questions you have.
11. Is there anything else you would like to talk about?

Interview 4- Post-placement

Consent & Logistics

- Thank participant for attending post-project interview.
- Interview will be recorded; notes will be taken.
- Confirm participant agreement for this including transcript remind of consent form.
- Post-project interview is scheduled to last for an hour.

Role, strengths & challenges

1. Tell me about your role and activity during the live broadcast.
2. What things did you enjoy during the placement?
3. What things were challenging during the placement?
4. How did you address those challenges?

Objectives & progression

5. Can you review your progress against the objectives you set.
6. How would you rate your current level for each of the skills or attribute areas?
7. Using the table can you select which skill level (basic, proficient, advanced) best describes your skill level against these eight placement specific skill areas?

Skills & personal strengths

8. What personal strengths did you draw upon during the placement?
9. What skills did you use and develop during the co-production process?
10. Has the placement provided any development opportunities towards your future career plans?

Teamwork & co-production

11. How did you find working with the team during the placement?
12. Can you reflect on how you found working in co-production (co-design, co-develop and co-deliver).

Future Thinking

13. If you were involved in another co-production partnership for a live fieldwork broadcast, what would you do differently?
14. What advice would you give anyone interested in a co-produced live fieldwork broadcast.
15. How else do you see student centered live broadcast be used within fieldwork education in higher education?

Mentor post-placement survey (2024 only)

Consent & Logistics

- Thank participant for attending post-project interview.
- Interview will be recorded; notes will be taken.
- Confirm participant agreement for this including transcript remind of consent form.
- Post-project interview is scheduled to last for an hour.

Structure for post-project interview

1. Tell me about your role and activity during the live broadcast placement this year?
2. What things did you enjoy about your role?
3. What things were challenging about your role?
4. How did you address those challenges?
5. Can you reflect on how you found working within the partnership this year?
6. What does being a mentor mean to you?
7. What skills did you use during your mentor role?
8. Has the mentor role provided any development opportunities towards your future career plans?
9. What helped you in your mentor role?
10. What other things would have been useful to help you in your mentor role?
11. Anything else you would like to share about your role in this year's live broadcast?

Appendix 4.2 Researcher reflective diary

Date	
Session	

	Researcher reflections and comments
Description	
Feelings	
Evaluation	

Appendix 5.1 Digital Field Notebook (DFN) Participant information sheet

Information Sheet Version 1/ Date 22/04/22 1

Researcher: Janine Maddison, School of Natural and Environmental Sciences
Title of Study: Assessing pedagogic benefits of the virtual world to enhance fieldwork.

Invitation and Brief Summary
You are being invited to take part in a research study. Before you decide whether or not you wish to take part it is important that you understand why the research is being done and what it will involve. Please read this information carefully and discuss it with others if you wish. Take time to decide whether or not you wish to take part. If you do decide to take part, you are giving your informed consent by completing the pre and post survey and using the app in the field. However, you are free to withdraw at any time, without giving any reason and without any penalty or loss of benefits.

What is the purpose of the research?
This research aims to use digital tools such as using technology in the field to address some of the challenges that learners face in conducting fieldwork within their studies.
The digital intervention has been designed to address these specific challenges and will go through two stages of evaluation. The first is a small-scale 'pilot' evaluation which will consider the process behind the adoption and use of the technology. The second larger scale impact evaluation which will aim to consider the impact of the technology intervention in addressing the underlying challenge experienced. This is the Impact Evaluation.

What does taking part involve?
- The participant will complete a short pre-fieldwork survey.
- The participant will trial the use of an app on a mobile device alongside the fieldwork tasks that are scheduled for the fieldtrip. The app collects and collates geo-located qualitative information and responses from the participant with the aim of developing deeper understanding of synoptic real-world learning, significance of the fieldwork task and deepening learners Nature Connectedness.
- After using the app during fieldwork the participant will be asked to complete a short post-fieldwork survey.
- Each survey should take around 15 minutes to complete.
- The principal researcher will conduct overt participant observations during fieldwork tasks.
- Informed consent will be sought.

Key themes included within the survey
- Fieldwork Observations and notetaking during fieldwork.
- Assessment of Nature Connectedness using the Connectedness to Nature Scale (Mayer & Frantz, 2004).
- Self-assessment of fieldwork skills: confidence and competency.
- Views on the use and value of technology in the field to enhance fieldwork knowledge and skills.

What information will be collected and who will have access to the information collected?
Any data and information submitted to app (Survey123) will be anonymous, all information submitted to the app will be collated and viewable by other participants of fieldwork at Newcastle University and for the purpose of the research project. Data may be uploaded to iNaturalist.
The survey will ask participants to disclose their stage of study and subject of study. Participants will be able to opt out of these questions.
No personal identifiable data will be collected.

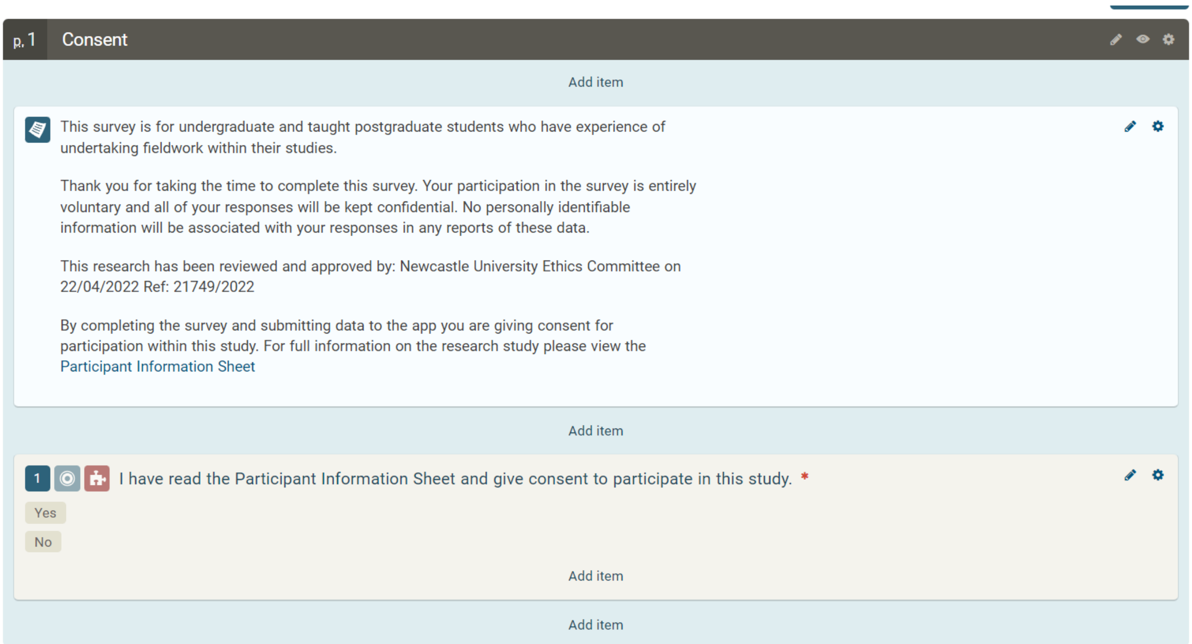
Participants will not be asked for information on sensitive information.
Data and metadata storage will follow the requirements and data protection of Newcastle University, which makes use of a secure online cloud storage with regular backups.
Individuals at Newcastle University may look at your research data to check the accuracy of the research study. The only individuals at Newcastle University who will have access to information that identifies you will be individuals who need to contact you to query a response or audit the data collection process.
If you agree to take party in the research study, your data will become part of a dataset which can be accessed by other users running other research studies at Newcastle University and in other organisations. These organisations may be other Universities. Your information will only be used by organisations and researchers to conduct research.

If you agree to take part in the research study the data provided will be de-identified and made available as "open data" through a research data repository https://research.ncl.ac.uk/rdm/sharing . This means the de-identified study data will be publicly available and may be used for purposes not related to this study. It will not be possible to identify you from the "open data".

Who is the sponsor and data controller for this research?
Newcastle University is the sponsor for this study based in the United Kingdom. Newcastle University will be using information from you in order to undertake this study and will act as the data controller for this study. This means that Newcastle University is responsible for looking after your information and using it properly. The lawful basis for carrying out this study under GDPR is Task in the Public Interest, (Article 6,1e) as research is cited as part of the University's duties.
Your rights to access, change or move your information are limited, as Newcastle University need to manage your information in specific ways in order for the research to be reliable and accurate. If you withdraw from the study, all information and data you have provided will be removed from the study. You can find out more about how Newcastle University uses your information at https://www.ncl.ac.uk/data.protection/ and/or by contacting their Data Protection Officer rec-man@ncl.ac.uk.

Who is funding this research?
Newcastle University
Has this study received ethical approval?
This study has received ethical approval from Newcastle University Ethics Committee on 22/04/2022 Ref: 21749/2022
Who should I contact for further information relating to the research?
Janine Maddison, j.l.maddison2@newcastle.ac.uk
Who should I contact in order to file a complaint?
Research Study: Sara Marsham, sara.marsham@newcastle.ac.uk
If you wish to raise a complaint on how your personal data is handled, you can contact the Data Protection Officer: rec-man@ncl.ac.uk
If you are not satisfied with their response you can complain to the Information Commissioner's Office (ICO): https://ico.org.uk/.

Appendix 5.2 Digital Field Notebook (DFN) Pre-fieldwork survey


p. 1 Consent

Add item

This survey is for undergraduate and taught postgraduate students who have experience of undertaking fieldwork within their studies.

Thank you for taking the time to complete this survey. Your participation in the survey is entirely voluntary and all of your responses will be kept confidential. No personally identifiable information will be associated with your responses in any reports of these data.

This research has been reviewed and approved by: Newcastle University Ethics Committee on 22/04/2022 Ref: 21749/2022

By completing the survey and submitting data to the app you are giving consent for participation within this study. For full information on the research study please view the Participant Information Sheet

Add item

1 I have read the Participant Information Sheet and give consent to participate in this study. *

Yes

No

Add item

Add item

p.2 Stage & Subject of Study

Add item

2 What is your current Stage of Study?

1st year undergraduate

2nd year undergraduate

3rd year undergraduate

Show all (6)

Add item

Add item

3 What degree subject are you studying?

Add item

Add item

p.3 Fieldwork Observations & Notetaking

Add item

This section will consider the role of note-taking during fieldwork.

Add item

4 When conducting fieldwork list the things that you think are important to record when out in the field.

Add item

Add item

5 What do you see as the purpose of making notes during fieldwork?

Add item

Add item

Jump

p.4 Nature Connectedness

Add item

This section will explore the concept of 'Nature Connectedness' and assess your level of feeling emotionally connected to the natural world.

Add item

6 To what extent do you agree with the following statements.

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	
I often feel a sense of oneness with the natural world around me.	○	○	○	○	○	
I think of the natural world as a community to which I belong.	○	○	○	○	○	
I recognise and appreciate the intelligence of other living organisms.	○	○	○	○	○	
I often feel disconnected from nature.	○	○	○	○	○	
When I think of my life, I imagine myself to be part of a larger cyclical process of living.	○	○	○	○	○	
I often feel a kinship with animals and plants.	○	○	○	○	○	
I feel as though I belong to the Earth as equally as it belongs to me.	○	○	○	○	○	+ Add question column
I have a deep understanding of how my actions affect the natural world.	○	○	○	○	○	
I often feel part of the web of life.	○	○	○	○	○	

I feel that all inhabitants of Earth, human, and nonhuman, share a common 'life force'.	○	○	○	○	○
Like a tree can be part of a forest, I feel embedded within the broader natural world.	○	○	○	○	○
When I think of my place on Earth, I consider myself to be a top member of a hierarchy that exists in nature.	○	○	○	○	○
I often feel like I am only a small part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.	○	○	○	○	○
My personal welfare is independent of the welfare of the natural world.	○	○	○	○	○

7 What does the term 'Nature Connectedness' mean to you?

Add item

Add item

p. 5 Fieldwork Skills & Technology in the Field

Add item

This section will explore the role of technology in the field and ask you to assess your confidence and comptency of some fieldwork skills.

Add item

8 Do you see value in using technology in the field?

Yes

No

Unsure

Add item

a Please explain your answer.

Add item

Add item

9 Do you think technology in the field can be used to enhance your fieldwork knowledge and skills?

Yes

No

Unsure

Add item

a In what ways can technology in the field be used to enhance your fieldwork knowledge and skills?

Add item

Add item

b Please explain your answer.

Add item

Add item

10 Please assess your current competency level of the following skills.

	Not at all skilled- cannot or never performed before	Not very skilled- can perform with guidance	Somewhat skilled- can perform independently but require guidance at times	Skilled- can perform independently without guidance	+ Add question column
Identifying organisms	○	○	○	○	
Explaining natural processes	○	○	○	○	
Identifying/describing habitats	○	○	○	○	
GPS/GIS use	○	○	○	○	
Reflection	○	○	○	○	
Observation	○	○	○	○	
Applying theoretical knowledge	○	○	○	○	

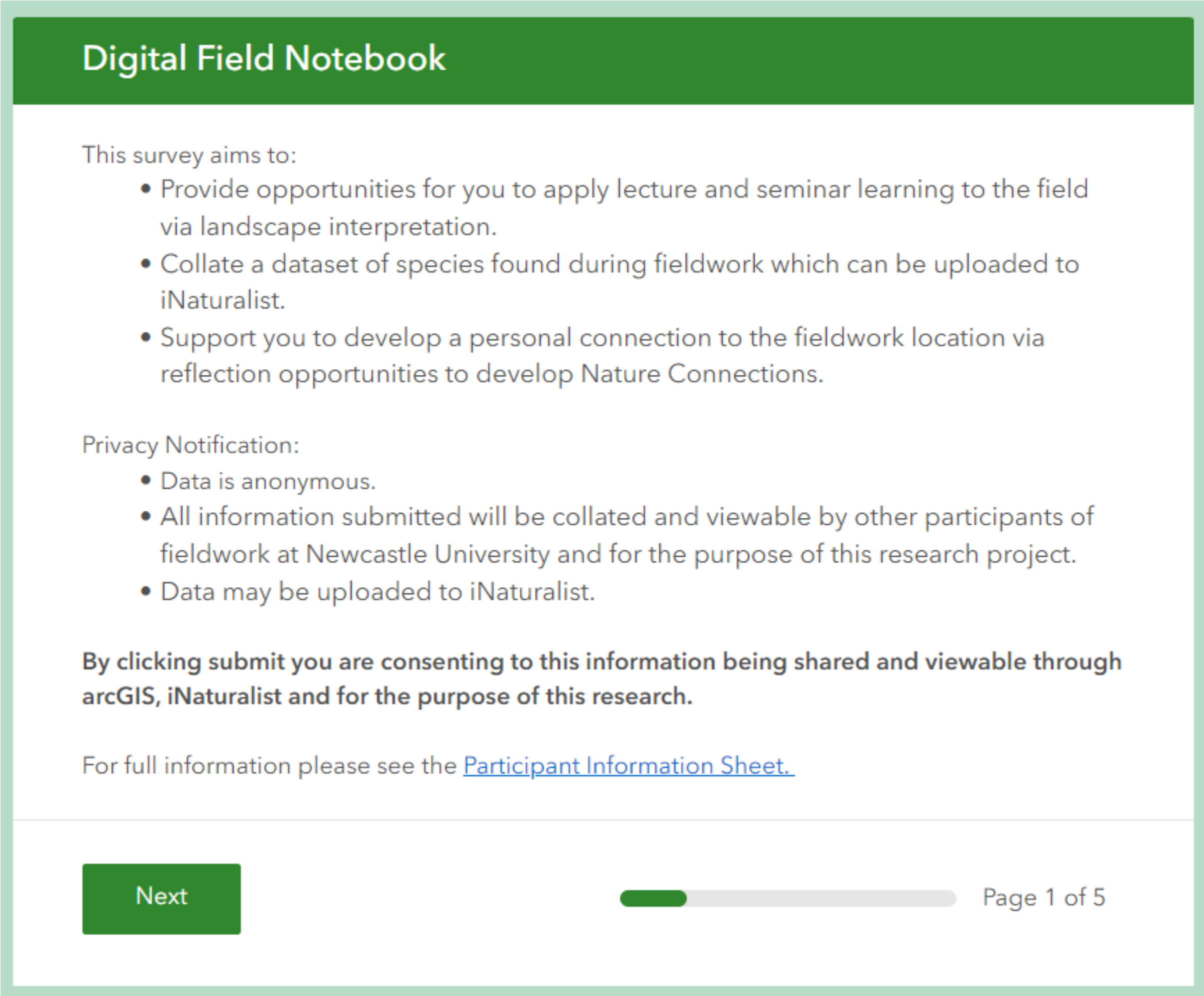
p. 6 Thank you

Add item

Thank you for taking the time to complete the survey.

Add item

Appendix 5.3 Digital Field Notebook (DFN) app interface



Digital Field Notebook

This survey aims to:

- Provide opportunities for you to apply lecture and seminar learning to the field via landscape interpretation.
- Collate a dataset of species found during fieldwork which can be uploaded to iNaturalist.
- Support you to develop a personal connection to the fieldwork location via reflection opportunities to develop Nature Connections.

Privacy Notification:

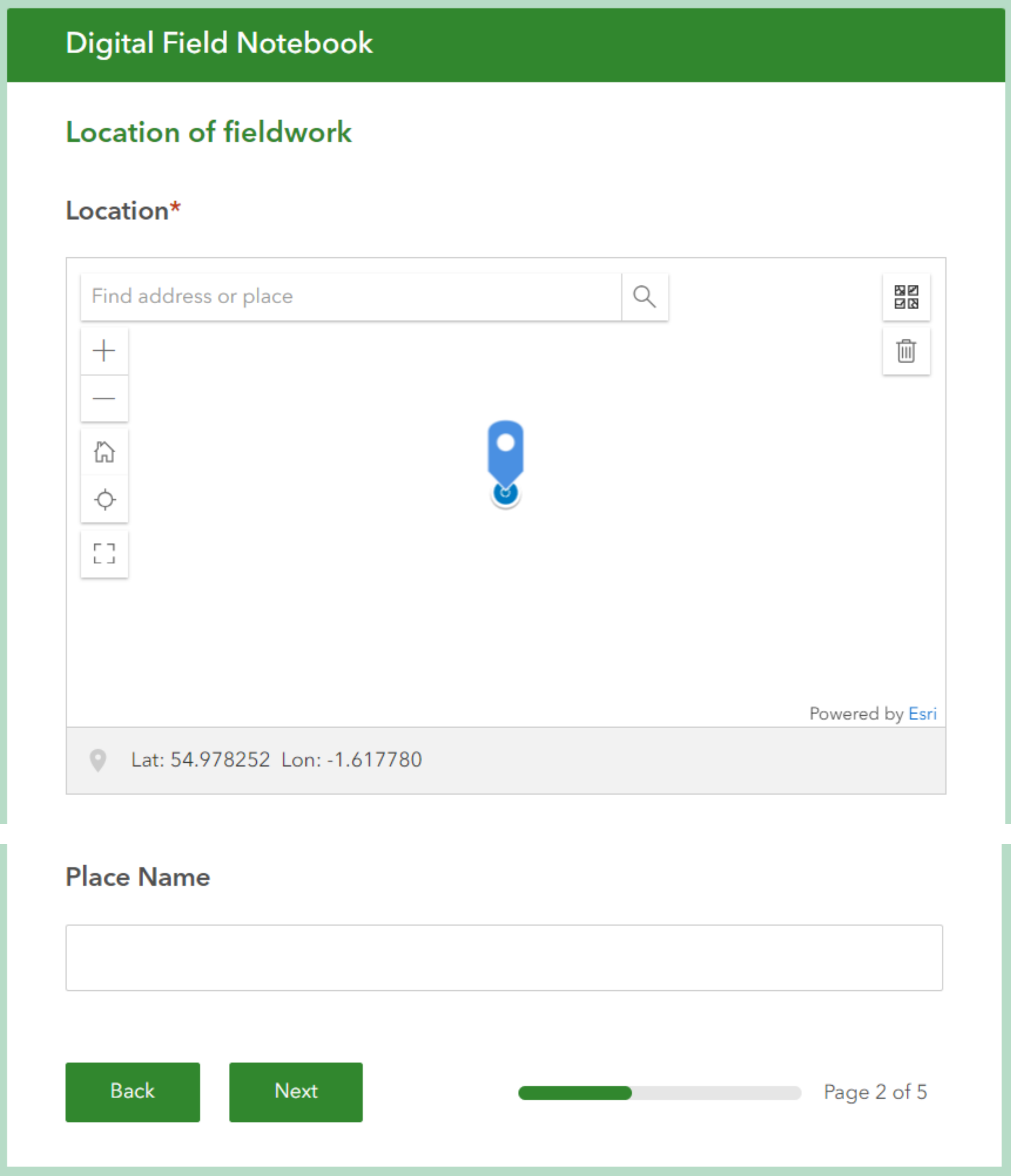
- Data is anonymous.
- All information submitted will be collated and viewable by other participants of fieldwork at Newcastle University and for the purpose of this research project.
- Data may be uploaded to iNaturalist.

By clicking submit you are consenting to this information being shared and viewable through arcGIS, iNaturalist and for the purpose of this research.

For full information please see the Participant Information Sheet.

Next

Page 1 of 5


Digital Field Notebook
Location of fieldwork
Location*
Find address or place
Powered by Esri
Lat: 54.978252 Lon: -1.617780
Place Name
Back
Next
Page 2 of 5

Digital Field Notebook

Species Identification

Record and submit some of the species that you identify during your fieldwork.

Species ID- Common name

Confidence of identification

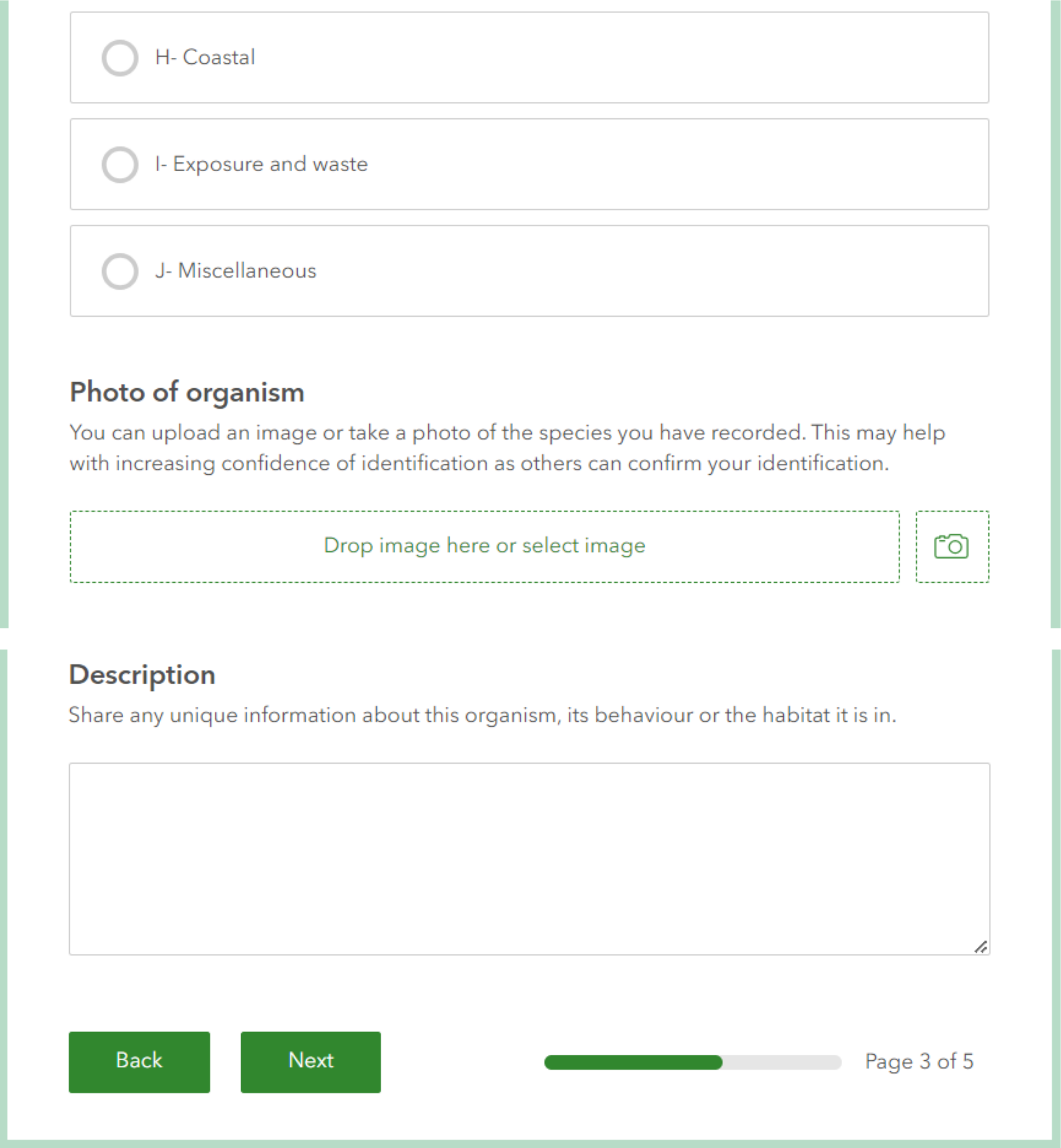
On a scale of 1-5 stars, how confident are you with the species identification of your record. With 1- not very confident and 5- extremely confident.

☆ ☆ ☆ ☆ ☆

Habitat

Using the Phase 1 habitat classification system. How would you describe the overall habitat of where your record is located?

- A- Woodland and scrub
- B- Grassland and marsh
- C- Tall herb and fen
- D- Heathland
- E- Mire
- F- Swamp, marginal and inundation
- G- Open water


H- Coastal

I- Exposure and waste

J- Miscellaneous

Photo of organism

You can upload an image or take a photo of the species you have recorded. This may help with increasing confidence of identification as others can confirm your identification.

Drop image here or select image

Description

Share any unique information about this organism, its behaviour or the habitat it is in.

Back Next

Page 3 of 5

Digital Field Notebook

Landscape Interpretation

Describe any patterns or features you can observe in the environment.

Consider what physical processes and human impacts are having the biggest impact in this environment. Why?

Back Next

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Digital Field Notebook

Nature Connection

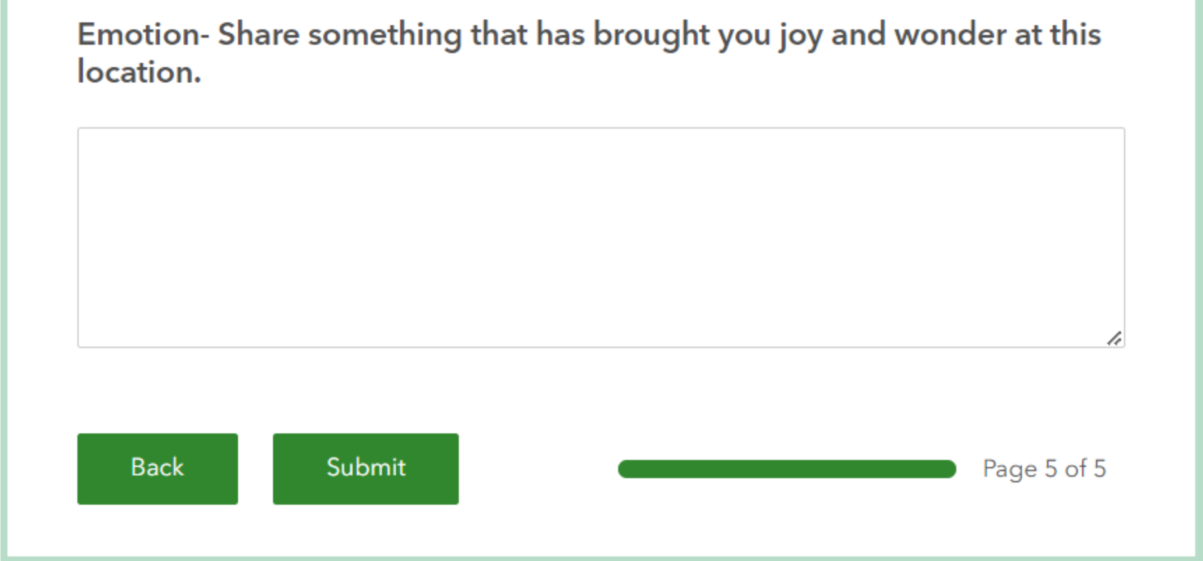
A new closer, healthier and more sustainable relationship with nature can be obtained by moving beyond just contact or engagement with nature.
The pathways to nature concept considers how our connection to nature can become more meaningful to an individual.
For more information: Pathways to Nature Connection

Beauty- 3 good things in nature

Record three good things in nature that you can see.

Meaning- How did these 3 good things in nature make you feel?

- ○ High energy positive e.g. excitement, joy, elation
- ○ Low energy positive- e.g. tranquillity, serenity and satisfaction
- ○ Low energy negative- e.g. boredom, sadness, despair
- ○ High energy negative e.g. anger, frustration, anxiety


Emotion- Share something that has brought you joy and wonder at this location.

Back Submit Page 5 of 5

Appendix 6.1 Training plan, participant information sheet and safer spaces agreement

Training plan

Key learning aims

- To increase awareness of different digital tools which can be used in fieldwork education.
- Support critical reflection on the opportunities, purpose and barriers of digital tool use in fieldwork.
- A chance to share ideas and collaborate with peers on the potential of digital tools to enhance fieldwork.
- Consider factors to support the designing and embedding of digital tools to enhance fieldwork.

Intended impact

- Attendees will have enhanced knowledge on a range of digital tools and their role in enhancing fieldwork education.
- Attendees will be able to critically reflect upon their existing fieldwork practice and identify opportunities for digital tools to enhance practice.
- Attendees will develop a digital action plan which includes personal and centre level action points.

Session details

Time	*Content*	*Outputs*
5 min	**Intro & welcome**	
5 min	**Consent for participation**	Informed consent to participate.
10 min	**Discussion** Current fieldwork practice Digital tools in fieldwork – purpose and barriers What can and should be enhanced	
20 min	**Off-the-shelf resources** Practical 1- Virtual Field Trips (VFTs) Practical 2- Preparing for fieldwork (specific/generic)	Access & engagement with resources.
20 min	**Adaptable resources** Practical 3- Digital Field Notebooks (DFNs) Live broadcast	Access & engagement with resources. Discussion of adaptations
10 min	**Other digital tools to enhance fieldwork** Participant sharing	Sharing and collating of ideas.
20 min	**3-step fieldwork planning tool** Defining current fieldwork practice Identifying gaps and potential	Mapping of existing practice using the tool. Sharing and uploading of maps and gaps.
5min	**Things to consider when embedding digital tools in fieldwork**	
20 min	**Development of digital action plan** Share & discuss	Digital action plans uploaded.
5 min	**Summary & close**	Q&A Complete post-training survey

Participant Information

Researcher: Janine Maddison, School of Natural and Environmental Sciences, Newcastle University.

Research study: This online workshop forms part of a research project (Assessing pedagogic benefits of the virtual world to enhance fieldwork) with the workshops acting as a research methodology.

What is the purpose of this research and training workshop?

This research aims to trial the use of digital tools to address some of the challenges that learners face in conducting fieldwork within their studies. This workshop forms part of the dissemination stage of the project.

- From the perspective of a training workshop, the researcher will act as a facilitator who prioritises participant need during the training workshop.
- From the research perspective, the participants, along with their contributions and outputs, become part of the research design and data. Participants and researchers work together, but with the researcher in control of content and pace of the session.

By registering for the training workshop you are agreeing to:

- participate in the practical activities and discussions throughout the training workshop.
- engagement metrics, comments, survey responses and digital actions plans to be used within this research.

What does taking part involve?

- Participate in the training workshop.
- Complete a digital action plan with personal and centre actions related to the use of digital tools to enhance fieldwork.
- Complete a short survey after the training workshop.
- Option to complete a case study in (Aug 2024).

What information will be collected and who will have access to the information collected?

Workshop

- Number of comments posted in Padlet.
- Content of comments posted in Padlet.
- Poll data.
- Review of current fieldwork practice.
- Digital action plans (personal and centre actions)

Survey

- The survey is designed to be anonymous, and any personal or identifiable information will be deleted.
- The survey will ask participants to disclose their job role, and number of years of experience facilitating fieldwork.
- All questions within this survey are optional.
- Participants will not be asked for information on sensitive information.
- The synthesised results (including anonymised quotes) will be shared via a research paper.
- Data and metadata storage will follow the requirements and data protection of Newcastle University, which makes use of a secure online cloud storage with regular backups. All identifiable data gathered will be kept confidential. Data is stored and processed in compliance with UK GDPR requirements.

Key themes of training workshop and survey

- Review of existing fieldwork practice.
- Views on the use and value of digital tools in fieldwork education.
- Critical reflection on off-the-shelf and adaptable digital tools.
- Actions to enhance existing fieldwork practice using digital tools.

Who is the sponsor and data controller for this research?

Newcastle University is the sponsor for this study based in the United Kingdom. Newcastle University will be using information from you in order to undertake this study and will act as the data controller for this study. This means that Newcastle University is responsible for looking after your information and using it properly.

The lawful basis for carrying out this study under GDPR is Task in the Public Interest, (Article 6,1e) as research is cited as part of the University's duties.

Your rights to access, change or move your information are limited, as Newcastle University need to manage your information in specific ways in order for the research to be reliable and accurate. If you withdraw from the study, all information and data you have provided will be removed from the study.

You can find out more about how Newcastle University uses your information at https://www.ncl.ac.uk/data.protection/ and/or by contacting their Data Protection Officer rec-man@ncl.ac.uk .

Prize draw

To thank you for completing the post-workshop survey, there is a chance to win a £50 Amazon voucher. Please provide your email address within the survey if you would like to be entered into the draw. One name will be selected at random from the list of completed surveys on 31/03/24. The winner will be contacted by email shortly after this date. If there is no response to the email within 2 weeks, a re-draw will be completed and a new winner announced.

Who is funding this research and training workshop?
Newcastle University

Has this study received ethical approval?

This study has received ethical approval from Newcastle University Ethics Committee on 25/01/2024 Ref: 41815/2023.

Who should I contact for further information relating to the research?
Janine Maddison, j.l.maddison2@newcastle.ac.uk

Who should I contact in order to file a complaint?
Research Study: Sara Marsham, sara.marsham@newcastle.ac.uk
If you wish to raise a complaint on how your personal data is handled, you can contact the Data Protection Officer: rec-man@ncl.ac.uk
If you are not satisfied with their response you can complain to the Information Commissioner's Office (ICO): https://ico.org.uk/

Safer Spaces Agreement

SAFER SPACES AGREEMENT

for 'Desiging and using digital tools in fieldwork education' workshop.

A safer spaces agreement is about creating an inclusive, welcoming, affirming and respectful environment so that all attendees feel able to participate freely and without fear. We ask everyone attending the workshop to read and respect the following guidelines.

Guidelines and expectations:

- Treat everyone with courtesy and respect.
- Think carefully before posting any deeply personal information about yourself or others.
- Be considerate an respectful to all attendees.
- Be mindful of your privileges and try to actively challenge them.
- Be aware of the range of different identities that people have and the range of different experiences in the workshop. Avoid making generalisations or assumptions about people.
- People are welcome to engage in dialogue, and ask questions.

Remember that the workshop is a learning environment. Where we hope participant will engage with the materials, the facilitator and each other.

Appendix 6.2 Social media assets for recruitment to the workshops and engagement metrics

Tile image for sharing via social media and newsletters.

Engagement metrics (as of 11/04/24) for the social media post advertising the participatory workshops.

Twitter/X post engagement		LinkedIn post engagement	
Views	4550	Impressions	512
Likes	32	Reactions	14
ReTweets	27	Reposts	4
Bookmarks	7		

Appendix 6.3 Digital Action Plan (DAP) template

Digital Action Plan

Area of development:

Personal or Centre-based

Why have you chosen this as a development area?

Objective	Action to meet objectives	Record of progress	How will you sustain/embed the development?

Appendix 6.4 Post-workshop survey

Enhancing fieldwork with digital tools: Post-workshop survey

Please complete this survey after completing the training workshop.
This survey will ask you to reflect on your response to the training, any learning that has occurred and any behaviour changes as a result of the training.

Consent

A copy of the participant information sheet has been shared with you prior to the training and can be viewed here: Participant Information Sheet

1. I have read the participant information and give consent to complete the survey. *

- ◯ Yes I give consent and wish to complete the survey.
- ◯ No I do not give consent and do not wish to complete the survey.

Virtual Field Trips (VFTs)

These questions will ask for your views and experiences of VFTs.

2. The training workshop has increased my knowledge of VFTs

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree

3. How often do you use VFTs in your current fieldwork teaching?

- ◯ Everytime
- ◯ Almost every time
- ◯ Occasionally/sometimes
- ◯ Almost never
- ◯ Never

4. After the training workshop how likely are you to adopt the VFTs into your fieldwork practice?

- ◯ Extremely likely
- ◯ Likely
- ◯ Neutral
- ◯ Unlikely
- ◯ Extremely unlikely

5. How would you define the role of VFTs in fieldwork?

Digital Field Notebooks (DFNs)

These questions will ask for your views and experiences of DFNs.

6. The training workshop has increased my knowledge of DFNs

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree

7. How often do you use DFNs in your current fieldwork teaching?

- ◯ Everytime
- ◯ Almost every time
- ◯ Occasionally/sometimes
- ◯ Almost never
- ◯ Never

8. After the training workshop how likely are you to adopt the DFNs into your fieldwork practice?

- ◯ Extremely likely
- ◯ Likely
- ◯ Neutral
- ◯ Unlikely
- ◯ Extremely unlikely

9. How would you define the role of DFNs in fieldwork?

Digital preparation resources

These questions will ask for your views and experiences of digital preparation resources.

10. The training workshop has increased my knowledge of digital preparation resources

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree

11. How often do you use digital preparation resources in your current fieldwork teaching?

- ◯ Everytime
- ◯ Almost every time
- ◯ Occasionally/sometimes
- ◯ Almost never
- ◯ Never

12. After the training workshop how likely are you to adopt the digital preparation resources into your fieldwork practice?

- ◯ Extremely likely
- ◯ Likely
- ◯ Neutral
- ◯ Unlikely
- ◯ Extremely unlikely

13. How would you define the role of digital preparation resources in fieldwork?

Live broadcast

These questions will ask for your views and experiences of live broadcasts.

14. The training workshop has increased my knowledge of live broadcast

- ◯ Strongly disagree
- ◯ Disagree
- ◯ Neither agree or disagree
- ◯ Agree
- ◯ Strongly agree

15. How often do you use live broadcast in your current fieldwork teaching?

- ◯ Everytime
- ◯ Almost every time
- ◯ Occasionally/sometimes
- ◯ Almost never
- ◯ Never

16. After the training workshop how likely are you to adopt live broadcast into your fieldwork practice?

- ◯ Extremely likely
- ◯ Likely
- ◯ Neutral
- ◯ Unlikely
- ◯ Extremely unlikely

17. How would you define the role of live broadcast in fieldwork?

Embedding digital tools

18. Were you inspired by the workshop to adapt any of the approaches to suit your own fieldwork practice?

19. In your experience are there aspects of fieldwork that present challenges to learners?

◯ Yes
◯ No

20. Please can you provide detail on these challenges?

21. In your experience are there barriers to fieldwork for learners?

◯ Yes
◯ No

22. Please can you provide details of these barriers.

23. Do you think any of the digital tools explored in the workshop could address any potential challenges or barriers?

◯ Yes
◯ No

24. Please can you summarise how you think these digital tools could address any potential challenges or barriers.

25. Please can you summarise why you think this.

26. What is your opinion on embedding digital tools in fieldwork?

Reflection

These questions will ask you to reflect on the usefulness of the training.

27. How would you describe your level of satisfaction with the training?

◯ Very dissatisfied
◯ Moderately dissatisfied
◯ Slightly dissatisfied
◯ Neutral
◯ Slightly satisfied
◯ Moderately satisfied
◯ Very satisfied

28. What were the most useful aspects of the training?

29. What were the least useful aspects of the training?

30. Did you learn anything new in the workshop?

◯ Yes
◯ No

31. Please summarise some of the key things that you learned during the workshop.

32. How will you use what you have learned?

33. Please summarise why you did not learn anything during the workshop.