Chapter 7
Interdisciplinary Collaboration

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Abstract The Digital Earth Project aims at a strong interdisciplinary collaboration of the various Earth science disciplines and data science, to foster digitalization and the application of data science methods. As this is a highly complex interdisciplinary endeavour that involves eight research centres and many scientists, a success evaluation was deployed after the first half of the project. A social science-oriented evaluation was conducted, in which a World Cafe and a survey were used to evaluate the success of the collaboration and opportunities for improvement. Results indicate a strong need among participating scientists to more clearly understand and advocate for the overarching goals, have more face-to-face interaction, optimize the use of existing research infrastructure, and develop a sound perspective for knowledge transfer and long-term continuation of the developed approaches. It was deduced that individuals shape the process and that digitization is more than just a technical matter, but depends heavily on individuals and the process of implementation.

Keywords Evaluation · World Cafe · Survey · Collaboration · Interdisciplinary · Earth System Science

7.1 Challenges

For Digital Earth, one of the biggest challenges was bridging the gap between different disciplines and achieving the project goals in an extremely heterogeneous environment of project partners, scientific concepts and vocabularies. The consortium decided to seek support from the authors as representatives of the social sciences who are scientifically concerned with interactions in heterogeneous groups and to examine and assess the interdisciplinary collaboration. This chapter presents the results of a World Café conducted with Digital Earth scientists from a social science

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L. M. Bouwer et al. (eds.), *Integrating Data Science and Earth Science*,
SpringerBriefs in Earth System Sciences,
https://doi.org/10.1007/978-3-030-99546-1_7

perspective to learn more about pitfalls, challenges, requirements and best practices for successful collaboration.

Mankind on the threshold of the digital age is facing fundamental challenges in the expansion of opportunities and further development of even more far-reaching key technologies. The core characteristics of the digital age, namely networking, cognition, autonomy, virtuality and the explosion of knowledge (Schieferdecker and Messner 2019) have embraced the scientific world long since.

Over the recent decades, emphasis has been placed on making the scientific process more open and inclusive for all relevant actors, within and beyond the scientific community, as enabled by digitalization (Dai et al. 2018). That said, digitalization is changing science fundamentally. This poses the challenge that different scientific communities have developed their own vocabulary, observation methods, concepts and models that need to be brought together to advance on the required digitalization and integration.

This growing plurality of knowledge can be also observed in the realm of Earth system science, in which—the current research has branched off in multiple detailed sub-disciplines that call for new forms of collaboration across the different research strands. In this context, digitalization is believed to play a central role in this effort to tie the "loose" ends. Undertaking digitalization within Earth system science, however, involves large amounts of data, necessitating streamlining across different scientific communities, which can offer new analytical possibilities and produces new sorts of decision support tools. The moment an innovation process such as digitalization is initiated, the organization on which it is brought onto undergoes an initial phase, which may appear chaotic. This stage, dubbed as "fuzzy front-end of innovation", plays a decisive role in the further roll out of this innovation process (Berghaus and Back 2017).

The speed of uptake of digitalization is determined by the way how the (science) network community deals with the new demands (Clegg et al. 2016). As a case in point, with starting the Digital Earth project, an already existing scientific community was challenged with a completely new situation; to conduct and advance "data science" with a set with unclear parameters. In general, such challenges entail the adaptation and alteration of user behaviour (Brenner et al. 2014), and the accessibility and usability of data and newly introduced technologies (Dery and MacCormick 2012; Berghaus and Back 2017). On a social level, during the institutionalizing of innovation, new practices, values, routines and social norms have to be developed; networks are powerful carriers for this (Clegg et al. 2016).

While most challenges of the Digital Earth project were clear from the onset, others surfaced through interaction with others and through collaborative reflection. A validation on a personal level is thus required to link system perspectives and worldviews with research approaches and to assess efficacy of collaboration (Chiocchio et al. 2012; Glassman et al. 2021). Indeed, engaging with other fields of research can be a time-consuming process. To facilitate the gap-bridging of the different knowledge realms, one tool is the world cafe method (Brown et al. 2010). It provides the opportunity to jointly identify the challenges and gain shared consensus together as a group. Furthermore, this consensus and related challenges are not only shared and

validated, but also recorded and by that formally acknowledged among the group as a whole.

The objective of this chapter is to present the results of an accompanying research evaluation, focussing on the social dimensions on the collective and individual level of the challenges in collaboration within the Digital Earth project. The results have shown several issues that can be improved on and to help address several of the above mentioned challenges.

7.2 Material and Methods

The present research was conducted by using a mixed-methods approach (Kelle 2014). An earlier survey, performed in April 2019 by the Digital Earth project for success evaluation, addressed the collaboration success by the then present requirements for data science, the scientific and project successes and the usability of results at that time (see also Chapter 6 in this book). The quality of collaboration was not assessed at that time. To examine the success of collaboration within Digital Earth in more detail, an online survey, more focussed on the social dynamic across different scientific disciplines, was conducted prior the 2nd Interim Meeting of the project in January 2020, as the was half-way. In this second survey, qualitative and quantitative metrics were deployed to identify potential collaboration barriers after Hanson (Hanson 2009). The findings of the online poll formed the pre-assessment stage which acted as baseline for the successive assessment steps. As such, during the 2nd Interim Meeting of the project in January 2020 itself, a World Cafe was conducted to assess trends and nature of collaboration among all attendees in more depth. The World Café, and to come up with proposals for potential improvements that would lead to better collaboration is a large group method, which contains a sequence of discussions at tables with 4–7 people seated at each table (Brown et al. 2010). The Digital Earth World Café consisted of 3 rounds, with each 3 questions, two of them in two versions, thus 5 questions in total. 49 scientists, engaged in Digital Earth, devoted effort in addressing those questions during the World Cafe. The questions evolved around the approaches and tools of collaboration, trajectories and trends, as well as on potential next steps. Central focus of the exercise was to gain insights on individual and collective views on the collaboration, and thus success, within the project. Also, potential areas for improvement for collaboration were identified.

7.3 Results and Discussion

In the following, highlights of the World Café discourses are collated and presented in a summative manner. **In round 1 and 2**, respectively, focus was placed on approaches and tools of collaboration as well as emerging trajectories and trends of collaboration.

It is a noteworthy aspect, that it was possible to distil four major thematic aspects across the first two rounds from the collected statement pieces. These 4 major groups were confirmed and strengthened during the final prioritization round:

1. *Project Goals*: a frequent mentioning and a clear feedback in the voting session suggested that not all participants were able to see the higher level and overall goals that were set for the project and hence voiced a wish for a clearer definition.
2. *Individual Level*: the wish for more personal interaction, interpersonal exchange and cohesion was clearly voiced and appeared in the statements on all tables and resurfaced in each World Café round.
3. *Infrastructure*: Although available access, clarity of structure within and understanding of the used platforms was identified as a major component of good collaboration, the use of the digital infrastructure (closer defined as GITHUB, Helmholtz Net, Confluence) and therefore the exchange of information between Centres was mentioned as a major barrier for collaboration. The major obstacles here appear to be the optimal use of the infrastructure which has been developed for the project. This includes the lack of sufficient overview of the various platforms, search options for people and information, guidelines for use and communication about these infrastructures.
4. *Knowledge Transfer and Continuation*: the participants expressed repeatedly the wish to see the application of the already produced project outcomes as well as the outreach to increase visibility for their product, and furthermore the continuation of the project after the prospective project end.

In **round 3,** a special focus was placed on the next steps in collaboration within Digital Earth, the results given to the question "In terms of collaboration, what should we do next?" showed the same prevailing dispositioning as in the first two rounds and were sorted in strategic and methodological suggestions or advice (Table 7.1).

Some of the statements are at the interface between two dimensions, e.g. "Introduce new members to everyone", applies to the infrastructural dimension, helping to find the right contact person, but also feeds into the personal dimension. "Develop and implement long-term-legacy plans" touches not only outreach and the big picture, but also the goals. The previously conducted online poll, aiming at the identification of potential collaboration barriers, mirrored this finding, as it showed that half of project members indicated that within a geographically wide-spread team, finding the right contact person is difficult. Furthermore, it supported the finding of an abundantly stated request for a clearer and more personal level networking as well as a high commitment and willingness to collaborate. This was somewhat reflected in the World Café's last round, in which ideas about next steps for future collaboration were collected and needed little support by the facilitator, as the notions seemed to be clear to the participants and motivation was high. In conclusion, the participant's statements during the World Café showed an overall coherence in their professional needs and the challenges which the project faces in the 2nd half. Intensified personal contact and subsequently refined alignments towards the mentioned themes were identified as prerequisites for the project's success. Furthermore, the wish for clearer defined goals and targets were highly abundant throughout the entire World Cafe. The

Table 7.1 Sorted statements from World Café round 3 in response to "In terms of collaboration, what should we do next?"

Dimension	Level	Statements given by participants
Individual	Strategic	– Communication of results, workflows, methods, mistakes, lessons learned – Don't settle with current status of collaboration, learn more ways to work with and familiarize yourself with others – Consolidate a shared language and common understanding
	Methodological	– Create a forum or board for exchange – Create examples for successful collaboration – Meeting more often, create opportunities to exchange, also among disciplines, because we learn better from others when meeting in person – Create an alumni network with regular meetings (e.g. DigitalEarth@Kieler Week)
Goals	Strategic	– We need common goals and targets – Define clear milestones – Reiterate common goals and communicate them
	Methodological	– Regular meetings with others to realign towards goals – Consolidation of targets and activities towards common goals (steering tasks)
Infrastructure	Strategic	– Make information available to participants – One selling point for information
	Methodological	– Promote existing platforms better, especially among new people – Integrate tools towards one framework – Overcome technical barriers (AAI, exchange of resources) – Component-based software implementation and design (defined interfaces) – Finding partners/people with similar issues search engine, look-up table, Digital-Earth-Wiki – Joint surveys and collaborative inter-comparison campaigns – Make use of the agreed methods and standards for communication, collaboration and co-working – Guidelines for using collaboration system – Advertise information sources to participants more often – Introduction of new members to everyone

(continued)

Table 7.1 (continued)

Dimension	Level	Statements given by participants
Outreach and Knowledge Transfer	Strategic	– Develop and implement long-term legacy plans – Reiterate the connections in the big picture – Find ways to continue collaboration post-Digital-Earth – Increase active engagements in larger scale data science/management activities – What do other projects need and what can we offer?
	Methodological	– Engage with other initiatives: what can Digital Earth do for you? – Define success stories and apply feedback to improve collaboration – Communicate and show results on simple and well-known platform (YouTube) – Document more: publicly and discoverable – Encourage Digital-Earth-members to broadcast their recent To-do's, tasks, aims, issues and problems – More visibility for MOSES and others: Campaign and data management – visibility of Digital Earth contributions – Who's who? (like google street view)

way how the shared web spaces are organized and the overall information accessibility was a common theme as well. The fourth thread was the wish for more outreach activities, the requirement to understand the future application and usage of the products from the project, as well as a clear perspective for the period after the direct project life-time including a possible further development of ideas and products.

7.4 Conclusions and Outlook

The discourses and reflection within the Digital Earth project function as a case study for the conditions in which human societies at large find themselves today; digital participation and networking enable a manifold of potential but also need to adhere to essential social mechanisms. These divergences also surface within science and on the perspectives of how to collaborate and streamline different data towards open science outcomes. The deployment of digital tools and methods alone does not guarantee a successful digitalization.

Two central issues could be identified:

1. Individuals shape the process: In essence, the findings uncover the hidden assumptions and biases each of the individual partaking scientists had regarding digitalization in Earth System Sciences. The discussions in the World Café exercise indicated that the background, experiences and personal knowledge of each individual seem to determine the definitions and views on how to collaborate in the project. Yet, tools may help to streamline some of the diverging initial definitions and ideas expressed at the World Café. In this context, the World Café proved to be a suitable method of positive engagement across different disciplines.
2. Digitalization is more than solely a technical affair and relies heavily on individuals, their understanding of collaboration and a harmonization of disciplinary perspectives and worldviews. While there was general agreement among researchers that biophysical knowledge remains critical in their work, the need for new digital capabilities and clear objectives on how to continue to merge science towards digitalization. The findings indicate that at a high abstraction level, the expectations of digitalization within the project were quite unequivocal across the different research disciplines. For instance, a similar understanding was portended that digitalization potentially leads to more productive, efficient and sustainable forms of data utilization and knowledge creation. However, this understanding of digitalization was hampered by the formulated need for a clearer definition of the related and required digitalization process within the different research organizations, which suggests that the project was in somewhat earlier stages of "digi-grasping" (Dufva and Dufva 2019) or what has been referred to as the "fuzzy front end of digitalization" (Berghaus and Back 2017).

In the light of the global challenges ahead, combined with the possibilities and requirements of the dawn of the digital age, not enough emphasis can be laid on the

investment in the underlying personal connections. The foundation of all interactions, always had and most likely will be for a long time, is the connection on an individual, personal level. By acknowledging this, digitalization in Earth System Science can, and most likely will be a highly potential tool for fostering meaning-making and understanding of the complex world around us.

Acknowledgements The authors would like to express their gratitude to all members of the Digital Earth project for their willingness to engage and share their views.

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