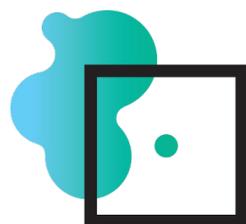


White paper

Transdisciplinarity in Digital Life Norway

8 October 2021

Maria B. Hesjedal and Roger Strand



**CENTRE FOR
DIGITAL LIFE
NORWAY**

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Background and mandate for this report

In 2014, the Research Council of Norway (RCN) launched its strategic initiative for biotechnology research called “Digital Life – Convergence for Innovation”. The Centre for Digital Life Norway (DLN) was created in 2015 as a national virtual centre for biotech research and innovation. At the time of writing the centre consisted of a national networking project, 17 directly funded research projects and 18 associated research projects, as well as a research school and a strategic innovation project. In 2021 the national centre has begun its second period, with more partners and an even clearer mandate to change the Norwegian biotech sector, by way of – metaphorically expressed – being a flagship and acting as a lighthouse.

In the original vision, the flagship and lighthouse character of the Digital Life initiative

was above all meant to rely on the development of a new style of knowledge production, characterised by the concepts of “integration”, “interdisciplinarity”, “convergence” and “transdisciplinarity”. Indeed, throughout the processes of policy development, planning and funding – as well as during the operational phase of DLN - the notion of transdisciplinarity has been emphasised: DLN research and DLN activities in general should be, or at least strive towards becoming, transdisciplinary. While the original strategic policy document for Digital Life (RCN, 2014) never explicitly defined transdisciplinarity as such, it was implicitly defined as a mode of collaboration and interaction between research disciplines that was “something more” than interdisciplinarity, with higher ambitions and with an aim of tighter integration of different types of knowledge in order to solve societal challenges:

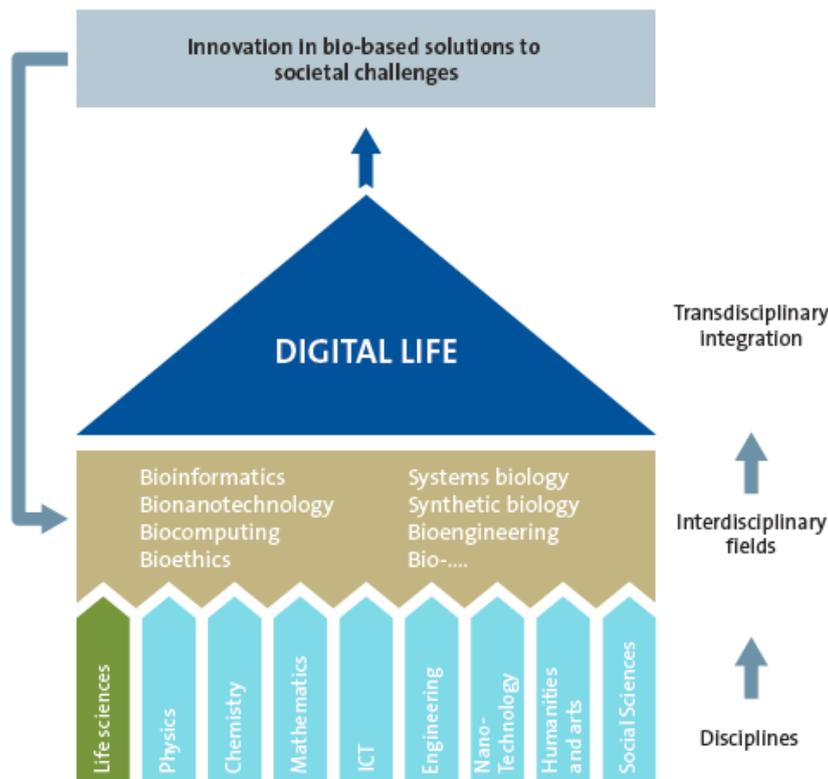


Illustration of the scope and content of the Digital Life – Convergence for Innovation initiative.

Figure 1: Illustration of the Digital Life Initiative (RCN, 2014, p. 8)

The range of disciplines considered relevant were almost unlimited, including life sciences, exact natural sciences, engineering, social sciences and the humanities. Furthermore, the RCN emphasized the role of other actors, including not only stakeholders in the value chain but also citizens in general, with particular reference to the science governance principle “Responsible Research and Innovation” (RRI).

The policy call for transdisciplinarity has been consistent and strong but with little specific guidance. Such a situation may give rise to a number of responses, from empowerment and creativity (“we are free to define transdisciplinarity ourselves”) to a sense of uncertainty and frustration (“we don’t understand what is expected from us”). The authors of this report have seen all of these responses in our work for DLN, and we have probably taken part in them ourselves as well. Neither within the DLN network project nor in DLN as a whole has there been any clear consensus on the exact meaning and role of transdisciplinarity; indeed, the term has been used in different ways, for different purposes and with varying intentional depth. In 2018, DLN and its member project Res Publica organised a so-called search conference in Selbu. A search conference is a method to facilitate long-term strategic thinking, and the Selbu conference was highly successful in this regard, gathering 32 participants from the DLN research projects and network project. At the search conference, the concept of transdisciplinarity and how to understand it was debated at length. Among the action points that were decided in Selbu, the first one was to clarify “the meaning and significance of transdisciplinary research and DLN vision.” This point addressed “a clear need to further clarify the DLN vision/mandate and the meaning of transdisciplinary research for identity building and for grounding change”¹. In 2020 the DLN network project created a task force to prepare the further work to meet that need. The members were Maria B. Hesjedal, Trygve Brautaset and Roger Strand. This report is the

result of that work. It contains a summary of how transdisciplinarity is defined in academic literature, which is rather different from the definitions used in and around DLN. Furthermore, it presents and discusses a set of experiences within DLN, from the research work within the centre and its attempts at creating transdisciplinarity in practice. Finally, based on these experiences, we provide a set of recommendations for the Centre for Digital Life Norway in its second period, 2021-2026, as well as its members (institutions and researchers) and funder (the Research Council of Norway). These recommendations should be interpreted as ideas for the future rather than prescriptions, and as expressions of the authors’ opinions and not of the institutions with which we are affiliated or by which we are funded.

The report was authored by Hesjedal and Strand, with frequent consultations with and advice from Brautaset, the Scientific Director of DLN. The first and main author is Maria B. Hesjedal. Her current research project explores transdisciplinary collaboration within DLN, and for this report, she contributed preliminary research results as well as valuable experience in the field. Furthermore, in the preparation of the report, a set of focus groups and other interviews were conducted in major Norwegian university cities to gather senior and early/mid-career researchers’ experience with transdisciplinary and other forms of collaboration within the DLN projects. Roger Strand contributed to the report, drawing mainly on personal experience with working for and within DLN since its conception in 2014 and inception late 2015. We are most grateful to Maria S. Meyer for her valuable comments and suggestions for improving the document.

Transdisciplinarity: Historical and academic backdrop

Transdisciplinarity is an increasingly favoured concept in research and research policy, largely because it indicates new ways of collaborating that can, hopefully, address complex societal

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https://www.digitallifenorway.org/news/documents/selbu_search_conference_2018.pdf

challenges. The concept of transdisciplinarity is a result of various historical developments, and in order to understand the concept and its roots it will be useful to review its historical background.

The number of scientific disciplines and sub-disciplines has grown rapidly for decades and more than a century. Increasing differentiation implies that we obtain ever deeper knowledge on highly specialised issues. However, with this development there is also a risk of “silos” and fragmentation of knowledge that creates barriers to dealing with complex societal challenges, sometimes referred to as “wicked problems” (Brown et al., 2010; Rittel & Webber, 1973). “Wicked problems” are characterized by their complexity and the difficulties of defining, addressing, or solving the problem at hand, often seen in contrast to “tame” or “benign” problems that are perceived as more readily defined and solved. The Coronavirus disease (COVID-19) pandemic is one example of a societal challenge that creates initiatives for new collaborations not only across scientific disciplines but also with business and public sectors. The climate crisis, loss of biodiversity, extinction of species, poverty and hunger etc. are other examples of such “wicked problems” (Bernstein, 2015; Brown et al., 2010; McGregor, 2015) which currently are presented as ‘grand challenges’.

In order to address the grand challenges, there have been many initiatives to overcome disciplinary boundaries. A common way of describing collaboration in science is by using concepts such as multi-, inter- and transdisciplinarity. There is no consensus on exact definitions of these terms; however, as a general observation the level of collaborative ambition increases from multi to inter to trans. In scholarly literature, **multidisciplinarity** is often defined by a mere juxtaposition of disciplines with multiple disciplinary goals under one thematic umbrella (Klein, 1990; OECD, 2020). **Interdisciplinarity** is, in contrast, often seen as interaction between two or more disciplines aiming for mutual integration of methods, data and organizing concepts (OECD, 1972). The concept of **transdisciplinarity** emerged closely connected to the environmental crisis during the 1980s both as a response to concerns about increased

specialization and compartmentalization of knowledge, and as a result of increased demands for interdisciplinarity also outside the universities (Bernstein, 2015).

Transdisciplinarity designates more comprehensive collaborative efforts than multi- and interdisciplinarity. In transdisciplinarity, the aim is to integrate different disciplinary knowledges, as in interdisciplinarity. “Trans”, however, signifies something more that goes beyond (transcends or transgresses) the interaction between disciplines. Usually, the prominent “transgressive” ingredient of transdisciplinarity is that it takes on board **experiential knowledge**, which may come from industrial actors, users, and/or relevant publics. “Trans-disciplinary” knowledge in this sense means knowledge that transcends what can be known by the academic world.

Transdisciplinarity in this sense has been gaining traction in the 21st century. In a recent report on promoting transdisciplinary research to address societal challenges, the Organisation for Economic Co-operation and Development (OECD) defines transdisciplinarity as “the integration of academic researchers from different disciplines with non-academic participants in co-creating new knowledge and theory to achieve a common goal” (OECD, 2020, p. 15). Transdisciplinarity has since the 1990s become an increasingly strategic concept in research policy documents in the EU and the US. Research policies promoting transdisciplinarity are often guided by a set of tacit underlying assumptions, and the OECD report is illustrative of many of the most common among these assumptions. The starting point of the report is the “number of societal challenges, often involving complex human-environment systems, that are not fully understood and for which solutions are urgently required” (p. 9). The OECD report is guided by a narrative where the solutions to complex societal challenges “cannot be generated based solely on disciplinary research but require a paradigm shift in research practice” (p. 9). It does not elaborate on what the perceived current problems with science and research are, beyond referring to the examples over and the UN Sustainable Development Goals. This narrative is repeated throughout the report, although it is not discussed in any detail.

Moreover, the narrative guides the suggested recommendations and solutions in the report. The OECD report presents two main arguments for why transdisciplinary research is needed: First, transdisciplinary research can address complex problems beyond the reach of traditional science, and second, transdisciplinary research can give rise to more innovative, holistic solutions (which is perceived as good). Value creation (not specified which values) is seen as one of the most important outcomes of transdisciplinary research, as, according to the report, it aims “to supplement and transform scientific insights for the good of society”. What this means in practice is not specified, but transdisciplinary research is seen as an essential tool for building and maintaining trust between science, policymakers and citizens. Other prominent narratives within the report include the importance of efficiency and the importance of upscaling.

For readers who are familiar with the concept of transdisciplinarity mainly from the RCN strategic initiative “Digital Life – Convergence for Innovation”, the OECD definition and the emphasis on experiential knowledge may come as a surprise. Indeed, in the figure reproduced above, there is no sign of experiential knowledge or non-academic stakeholders. Instead, “transdisciplinary integration” seems to be depicted as just another turn of the wheel of interdisciplinary integration; as long-term collaborations that gradually dissolve disciplinary borders. While this “non-trans-academic” conception of transdisciplinarity is not major or dominant, it does exist in the academic literature (Nowotny et al., 2001) as what is more frequently called “Mode 2 research”. Both Mode 2 research and transdisciplinary research are problem- or goal-oriented. The pursuit of the goal is more important than satisfying purist disciplinary standards, which – in the analysis of Nowotny et al. (2001) – creates tensions for scientists who want to combine Mode 2 research with academic careers in disciplinary universities. While the idea of Mode 2 certainly does not exclude experiential knowledge, it is not seen as a defining ingredient. A research practice may accordingly be both transdisciplinary research

(in the OECD sense) and Mode 2 at the same time.

Moreover, academic and policy-oriented literature on modes of collaboration in knowledge-production tend to be both descriptive and more or less normative. Specifically, there is a tendency to argue in favour of more collaboration and new forms of collaboration. In practice, too, it can be rhetorically difficult to argue against collaboration: “the more the merrier”. For a concrete context such as DLN, some care is needed to distinguish between the general value of collaborative spirit and the specific argument for why a particular mode of collaboration should be chosen in order to obtain a particular objective. On the general level, trans- is more ambitious than inter-, and inter- more ambitious than multi-disciplinary. In a specific case, however, multidisciplinary might be the right tool for the job; or perhaps the job is best done by researchers from one single discipline. Moreover, it should be remembered that multi-, inter- and transdisciplinarity are qualitatively different modes of collaboration, and there is not a linear process automatically leading from multi- or interdisciplinarity to transdisciplinarity. In other words, “very much interdisciplinarity” does not by itself become transdisciplinarity. We should be mindful of these observations as this report moves into the context of DLN.

Ideas of transdisciplinarity and convergence in the life sciences

The life sciences have – in particular on the research policy level - increasingly focused on the need for problem-solving collaboration and the concept of transdisciplinarity. Interdisciplinarity, transdisciplinarity and convergence are all terms heavily featured in life science policy documents and strategies governing and steering life science research toward more collaboration. The current research policy landscape in the US and EU aiming for disciplinary transgression (EC, 2014, 2017, 2020; RCN, 2014; Sharp et al., 2011) is a result of the historical trends mentioned

above.² In these research policies, the terms transdisciplinarity and convergence are in particular used to indicate a more comprehensive and integrated form of collaboration than multi- and interdisciplinarity. Though often used as synonyms, there are important distinctions between the two. Whereas convergence in this context mainly is focused on transgression within the sciences (much like Mode 2 research), transdisciplinarity in its most common definition has a wider scope that also includes incorporating knowledge from other (non-academic) actors.

The social study of collaboration in the life sciences has so far resulted in a plethora of strategies for studying problems across disciplines. There is, however, an “absence of a concise and coherent narrative on what collaboration and cooperation in the life sciences means” (Parker et al., 2010, p. 5). This is often perceived as a barrier for efficient collaboration. The language and narratives used in policy documents and governance from “above”, at the level of authorities and research funding organisations, often differ from the language at the practice level, in research performing organisations. Scholarly literature has shown that translating policy to practice is not straightforward. Scholars argue that “effectively supporting and encouraging new forms of collaboration in the life sciences requires new and innovative ways of thinking about the development and implementation of science and technology policy” (Ibid., p. 5).

The Norwegian life science landscape must be seen in this context. In line with European calls for increased collaboration and disciplinary transgression, the last decades of development in the life sciences has been taken to indicate that new forms of collaboration are required. One major challenge is the rapid rate at which the life sciences generate data without having the tools to analyse it all. The solution to this perceived problem is increased collaboration between the biological and the physical sciences (mathematical, numerical and modelling).

Within the same time period, the research policy discourse of “grand challenges”/ “societal challenges” has gained momentum, prescribing that scientific research should be more actively steered so that it becomes more relevant and produces solutions to society’s current challenges. The suggested solution to this problem, too, is more intensive and new forms of collaboration. It can be argued that the Norwegian Digital Life initiative combines both of these motifs into a broad call for a “transformation of the Norwegian biotechnology landscape” into a landscape of transdisciplinarity.

Norwegian biotechnology from FUGE to DLN

In 2002 the RCN launched the Programme on Functional Genomics in Norway (FUGE), the Council’s widest-ranging strategic initiative, with an overall budget of NOK 1.6 billion for the period 2002-2011 (RCN, 2012). The FUGE programme was in 2012 followed up by BIOTEK2021, a programme meant to continue the considerable investment in Norwegian biotechnology. BIOTEK2021 was intended to follow up on activities from FUGE and to expand further, incorporating a significantly greater focus on innovation and value creation (RCN, 2014, p. 5): “The BIOTEK2021 programme has a distinct innovation-oriented profile. The objective is to generate biotechnology that contributes to innovation and subsequent value creation in order to solve societal challenges in a responsible manner”. The programme would run from 2012 through 2021. BIOTEK2021 would also contribute to the implementation of the Norwegian government’s national strategy for biotechnology (RCN, 2012).

The Digital Life Initiative

As part of the programme, BIOTEK2021 launched the strategic initiative “Digital Life – Convergence for Innovation”. The strategic initiative was inspired by international developments, as well as the FUGE programme, and is an attempt to create a “transformative and long-lasting effect on biotechnological

² There are significant differences between US and EU research policies in many regards, but both have increasingly focused on overcoming disciplinary

boundaries to increase efficiency and create value in their respective contexts.

research and innovation in Norway” (RCN, 2014, p. 5). The digital life initiative was intended to be the programme’s most comprehensive and integrated effort, aiming to create economic, societal and environmental value for Norway: “to promote responsible innovation and value creation by encouraging more extensive and closer cooperation between biotechnological research groups and researchers in other disciplines and technology areas” (Ibid., p. 3). The Digital Life initiative is built on the assumption that there is a current inability to understand and control highly complex biological systems, as well as the production of large amount of data at an unexpected rate. This is perceived as a problem, and something “biotechnological innovation is severely hampered by” (Ibid., p. 7). According to the RCN this calls for new methods, concepts and research constellations. In the strategy document it is stated that interdisciplinary areas within biotechnology have emerged as a response to the challenges of understanding complex biological systems. The RCN applauded this development, and the document calls for increased collaboration between - and integration of - disciplines inside and outside of biotechnology, focussing on the concept of transdisciplinarity.

Important for our analysis, one may distinguish several problems, challenges, and purposes for Digital Life addressed in the initiative:

- A. Increased (monetary) **value creation** from Norwegian life science, contributing to the bioeconomy
- B. Contributions to solving grand **societal challenges**
- C. Contributions to making biotech innovation (more) **responsible**
- D. Catching up with international research trends of **digitalization** and **convergence** between “wet/soft” and hard/numerical natural sciences, and better analysis and utilisation of big data sets from experimental life sciences.

For this set of rather different challenges, the Digital Life initiative envisioned a unified

solution, namely increased, intensified and novel modes of collaboration. This solution was given the overall general label of “transdisciplinarity”.

Centre for Digital Life Norway (DLN)

In 2015, as part of the Digital Life initiative, the Centre for Digital Life Norway (DLN) was established. DLN is a national centre for biotechnology research funded by the Research Council of Norway (RCN). In terms of funding, the DLN represents a substantial public investment of approximately 500 million NOK. The DLN mission is “to serve as a flagship in creating a vibrant, transdisciplinary digital life community (...) responsible for a varied transdisciplinary research project portfolio.” (RCN, 2014, p. 13). The network project often use the word ‘Transdisciplinary’ when describing the centre, as illustrated by the self-presentation on the DLN website: “The Centre for Digital Life Norway transforms Norwegian biotechnology research and education to increase innovation and value creation for society. The centre has research projects all over the country. Transdisciplinary collaboration is our trademark.”³

In order to understand how transdisciplinarity in practice is a key focus at the centre, some additional information on the DLN organisation is required. The DLN was organized as a virtual centre, originally mainly hosted by one institution (NTNU), functioning with support from the other universities (mainly UiO and UiB in the first phase). As mentioned above, the centre consists of research projects, a competence hub (formerly organized as the network project in DLN’s first funding phase), a research school and a strategic innovation project. It is furthermore equipped with various levels of governance, including a board of owner representatives (mostly universities), an international scientific advisory board and the usual layers of governance implied by its financial contract with the RCN. There are around 35 large projects at the centre led by universities and research institutes, currently half of which received

³ <https://www.digitallifenorway.org/>

financial support from the Research Council of Norway under the DLN funding programme. The research projects combine biotechnology with digital technology in health, aquaculture, agriculture, and industrial biotechnology. The competence hub is in charge of the everyday tasks at the centre and is organized into competence areas (formerly structured as work groups). For the current funding phase known as DLN 2.0, these are as follows: responsible research and innovation, data and models, innovation and industry, training and career development (including the DLN Research School), communications, and centre management. The DLN board consists of representatives from its partner research institutions and two representatives from industrial partners. The research school (DLNRS) offers training and education for early-career researchers (PhD students and postdocs). The Scientific Advisory Board (SAB) consists of international experts with experience in the life sciences and with similar experiments to the Digital Life initiative. The SAB's task is to support DLN by providing recommendations on academic matters, and matters concerning the internal operation of DLN as well as DLN's national network.⁴

The centre is the result of an ambition "to create a dynamic environment where academics, industry and interested publics are invited to collaborate" (RCN, 2014, p. 14). Though the policy expectations of transdisciplinarity are clearly stated in the Digital Life strategy document underlining the Centre, what transdisciplinarity should mean in practice was never precisely defined. In addition, there is the question what transdisciplinarity means in the particular context of DLN. The RCN largely left to the DLN Centre to answer this question and decide how transdisciplinarity should be achieved in practice. The document at hand is the result of a work mapping out and analysing the transdisciplinarity efforts in the DLN context, addressing both the term itself and the practices at the centre.

What has the word "transdisciplinarity" come to mean in DLN?

We shall begin this part of the report with an anecdote. One of the authors of this report (Strand) took part in the kick-off meeting of one of the first DLN research projects. The project group consisted of researchers from several disciplines, though with two main types of expertise: experimental biology and mathematics. It was clear to Strand that in that meeting, the mathematicians and biologists struggled to fully understand each other, and it was commented that it was likely to take time to establish an interdisciplinary collaboration. In the years that followed, however, progress was evident both for the researchers themselves and Strand as a spectator. They gradually developed shared understanding and a set of common concepts. The project resulted in novel mathematical approaches that served the biological questions well.

Regardless of whether that research project is an example of multi-, inter- or transdisciplinarity, it can be thought of as a success story for DLN. It did produce novelty, and it did so through a new collaboration between "hard" and "soft" natural sciences. Moreover, that project had a very active RRI ingredient. We believe that few scholars would call it a transdisciplinary project; more likely it was interdisciplinary. Transdisciplinarity, however, was a concept introduced "from above", from the funding side, and as a desire or need felt by the researchers.

We do not include this anecdote to argue that transdisciplinarity is unimportant or irrelevant. Rather, we wish to emphasize that the following three questions are entirely different in scope, and this report focuses on the third:

1. *Have DLN projects and activities been overall successful? ≠*
2. *Have DLN projects and activities achieved transdisciplinarity (in the scholarly definition of transdisciplinarity)? ≠*

⁴ <https://www.digitallifenorway.org/about/>

3. What has the word “transdisciplinarity” come to mean in DLN?

The first question is wholly outside the scope of this paper and was addressed by the DLN midterm assessment, which concluded that DLN overall had a successful first period. The second question is mostly outside the scope of this paper. To fully answer it, one would have to perform an impact assessment of a representative set of research projects and DLN events and activities. We have not made such an assessment and believe that it is too early to do so. Inter- and transdisciplinarity are slow achievements and should be assessed also in terms of long-term research collaborations.

The third question is somewhat easier to answer and pertains directly to the mandate of this white paper, which is to clarify the concept of transdisciplinarity and relate to actions and discussions within DLN. In the next section, we shall present interview material and reflections that shed light upon how transdisciplinarity is understood by DLN researchers. In this section we focus on the DLN competence hub and its events and activities, and notably those that use the concept of transdisciplinarity. Such initiatives are available for all DLN members, and include the DLN annual conference, the award for best transdisciplinary publication of the year, and seed funding for cross-project collaborations. Moreover, the Digital Life Norway Research School (DLNRS) is a possible arena for transdisciplinarity at the centre. The document at hand must also be considered a part of the centre’s work with transdisciplinarity.

Our main conclusion is that most events and activities that we have analysed, can be considered **interdisciplinary** initiatives that aimed at increasing collaboration between the scientists in the centre. With few exceptions, we have not identified the use of methods and specific approaches to promote or enact transdisciplinarity in the OECD sense, or Mode 2 research. The occasional presence of speakers at annual conferences external to academia and/or biotechnology as well as the increasing

use of industry internships may in the long term be conducive of transdisciplinary knowledge production (cf question 2 above) but do not seem to have been employed with a specific rationale of creating transdisciplinarity. Similarly, the prize for transdisciplinary publication as well as the seed funding mechanism seem to have supported inter- and not transdisciplinary research.

The Digital Life Norway Research School (DLNRS) deserves its own mention in this regard. While having its separate funding, it is tightly associated with DLN. As a research school it has been highly successful in terms of recruitment, with more than 450 PhD and postdoc members (April 2021). The research school is open to all early-career researchers working within the field of biotechnology in Norway, including those who are not part of DLN-funded projects. The ability to provide excellent research training and networking in the DLNRS is perceived as an important accomplishment for the entire Digital Life mission and the centre. It provides its members with annual conferences, general as well as scientific courses, travel grants, networking opportunities, reading groups, and connections to industry. As such the research school is seen as instrumental in creating a transdisciplinarity digital life community in line with the DLN mission (RCN, 2014). The research school is expected to offer “transdisciplinary training and education for the future of biotechnology” and aims to “help create opportunities for promoting transdisciplinary integration, building a culture for innovation, and creating a new collective team spirit among all younger scientists who are connected to the Digital Life initiative”⁵. For example, in 2020 it offered the so-called DLN signature course, “Transdisciplinary life science – a Digital Life Norway course”. This as many other courses in 2020-21 had to adapt to the COVID-19 situation and change parts of its schedule and content. We believe it is fair to say, however, that both the original plan and the actual course mostly offered methods and tools to develop inter-

⁵ <https://digitallifenorway.org/dlnrs/about>

rather than transdisciplinarity in the sense described above.

Results from research conducted by the first author of this report (Hesjedal) indicate that the research school has been an important arena for many of its members. Examples include PhD students who identify themselves more with DLNRS and DLN than their own department, and/or describing DLN as crucial for having a scientific network with people working on similar or related projects. This can be illustrated by the following quote by a PhD student describing how the research school has contributed in his PhD work: “The DLN, or really the [DLN] research school is where I have my network, and where I feel I belong. I don’t have a large network in my department, and I feel much more at home in the research school”. Another PhD student who was participating at the DLNRS annual conference in 2019 for the first time, not knowing anyone in advance, said: “I’m so happy that I decided to come here! In my daily work no one, not even my supervisor, knows what I’m doing. Here I have met several people doing similar things that I now can get in contact with when I need to discuss my work”. These are but two accounts sharing the positive sentiment of being or becoming part of a bigger network and community.

The value of this sense of community and identification with the research school should not be underestimated. The research school appears to have been highly successful at creating a relevant interdisciplinary meeting place. The research school is also seen by the members as a place where early-career scientists can acquire what they call “soft skills.” Such skills are not taught in universities, but are nevertheless considered important, especially for scientists who wish to follow a career outside of academia. In this context “soft skills” are used by the scientists to refer to communication, stress and time management, working with others, etc. In our work with this report, we have not encountered indications of impact towards transdisciplinarity in the academic sense, though.

The events do, however, show extensive work to facilitate interdisciplinary collaboration within the centre. In this regard the events seem to have been quite successful, especially

in creating meaningful arenas for the researchers at the research school, who were all at an early stage in their careers.

In sum, we can answer question 3 above: In the context of the DLN network project, our analysis indicates that the word “transdisciplinarity” has so far mainly come to mean interdisciplinarity in the scholarly sense.

DLN researchers’ experiences of engaging with transdisciplinarity

For this report, a set of individual and focus group interviews were carried out, in which DLN researchers (both senior/PI level and early/mid-career) were invited to reflect on their experiences with different forms of collaboration, including inter- and transdisciplinary collaboration. A general call for participation was announced in the DLN network in major university cities, and interviews were performed with those who agreed to participate. The interviews were broad and encompassed topics such as obstacles, needs and good practices. It should be noted that the informants essentially self-recruited by agreeing to participate. The findings can as such not be extrapolated to claim representativity for the entire DLN community. Rather, the findings are useful to spark reflection and debate.

The full results will be published in the appropriate form in a scientific communication. For this report, however, preliminary results of particular relevance are presented, and they mainly fall under two or three topics. The first topic is the understandings of transdisciplinarity. The second and third both are related to time factors in collaborative research projects. In addition, we present findings that show possibilities (potential for improvement) for better aligning transdisciplinarity with DLN’s other focus areas - innovation, industry collaboration, digitalization and RRI – in order to harvest synergy effects between them.

Understandings of transdisciplinarity in DLN

We have been able to discern three distinct understandings of transdisciplinarity that were expressed in the interviews performed for this

report. A plurality of understandings was unsurprising in light of the Selbu search conference that formed the mandate for this report. When discussing these understandings that we encountered, it is essential to keep in mind that the scholarly definitions presented in the introductory part of this report should not be seen as the “truth” on what transdisciplinarity “really” is or should be. There is no right and wrong in this issue. Recalling that the term “transdisciplinarity” effectively was imposed on Norwegian biotechnology from above (the Research Council of Norway and structures above them), albeit for good reasons, it is entirely reasonable that DLN actors themselves develop their own understanding of this term. This was indeed also the mandate that they/we were given by the RCN.

It seems useful, however, to clarify language to avoid misunderstanding and confusion. Such a clarification is important if DLN wants its members to pull in one direction, as different types of collaboration require different approaches to succeed. A clarification can also benefit the centre, as it will improve its chances of successfully facilitating the desired modes and kinds of collaboration. Hence, we distinguish between the following understandings of transdisciplinarity encountered in our interviews:

1. Transdisciplinarity in DLN is increased (interdisciplinary) collaboration between the natural science disciplines. This was the most prominent understanding in the interviews. In terms of scholarly literature, it corresponds to the standard definition of **interdisciplinarity** and alternatively Mode 2 research.
2. Transdisciplinarity in DLN is collaboration with disciplines far from your own, notably between the natural sciences on one hand, and the social sciences and humanities on the other. This was sometimes but not always referred to as collaboration with “the RRI people”. In terms of scholarly literature, it corresponds to the standard definition of **radical interdisciplinarity**.

3. Transdisciplinarity is “something more”, also including actors outside of academia. In terms of scholarly literature, it corresponds to the standard OECD definition of **transdisciplinarity**.

We have not been able to discern patterns in how understandings may vary between, say, early-career, mid-career, and senior DLN researchers. If anything, early-career researchers were perhaps more explicit about finding the concepts difficult to relate to because they are used so differently.

Collaboration between numerical/modelling sciences and experimental life sciences

A main goal of the Digital Life Norway initiative was to instigate and further develop collaborations between numerical and modelling sciences (e.g., physics, bioinformatics, mathematics) with experimental (“wet lab”) life sciences. As expected from the literature on interdisciplinarity, such collaborations are found to be demanding and require time and effort. We would like to emphasize one highly specific challenge that was brought up in the interviews and discussions also because it points towards a clear potential for improvement. The challenge is that early-career researchers within the numerical/modelling sciences who work on temporary contracts, are particularly vulnerable to delays in the experimental parts. This issue was voiced primarily by the early-career researchers themselves, but was also brought up by senior researchers and project leaders. Several accounts from early-career researchers described situations where they could not publish their papers as expected during their temporary contract period because of delays or problems in other work packages. Because of these delays the researchers did not have timely access to essential data material for their projects. There were also other accounts of similar situations describing problems with the synchronization between experimentalists and the modellers. We believe such observations can suggest concrete measures for improving project design and even more to research funders: They point towards the need for the

possibility of longer overall project periods as well as more redundancy in the job description and job opportunities for early-career researchers.

Synergy effects between DLN focus areas

When asked about the connection between transdisciplinarity and other focus areas of the DLN (with emphasis on innovation, industry collaboration, digitalization and RRI), most of the consulted researchers saw these as separate focus areas, and not necessarily linked together with each other or with the research being done in the project. One example is a postdoc's phrasing of how (s)he thinks the different DLN focus areas are connected: "Honestly I don't know, but if you asked me about trans- for example, in my case, AI and responsibility and innovation they are different things altogether." Some of the scientists supposed the focus areas in theory could be linked together, but stressed that because the areas were different parts of the project - and therefore would be measured according to different criteria - they would often in practice become separated. The accounts from the scientists suggest a potential for aligning transdisciplinarity with DLN's other focus areas in ways that can better harvest synergy effects between them. One possible way of approaching this is to clearly articulate the connections by showing how collaboration is a common denominator in all focus areas and allocate resources to carefully attend to these connections. This could be a first step in aligning ideas and practices in DLN, and ensure continuity and an overall plan for the centre's collaborative efforts.

RRI and innovation were the two most discussed focus areas in relation to transdisciplinarity. The DLN focus on innovation was questioned by some informants, and they challenged the need for it as well as the way it had been pursued at the centre. Other informants expressed positive views on innovation as an idea, and of being pushed to learn something new. At the same time, they pointed out tensions between what they described as research components and innovation components of the project.

RRI was also frequently brought up by the participants. It was often described as "something new" that they associated with the centre. Above all, participants in projects with researchers from the social sciences and humanities (sometimes referred to as "RRI persons" by the participants) connected RRI to transdisciplinarity, then typically understood as radical interdisciplinarity.

In this context another crucial aspect enters the discussion, namely time and its use in research projects. Time – and particularly the lack of it – was frequently brought up by the participants as a major obstacle for achieving well-functioning collaborations and scientific outcomes, and it should therefore be addressed in the DLN context. Interviewees described time limitations as a substantial obstacle to interdisciplinarity. Time was also perceived as an issue with RRI. Though often described as rewarding, having "RRI people" in the project was experienced as time-consuming, taking time from the "real science". This was a recurring point, though problematized in one of the discussions where two senior researchers discussed the challenge of allocating time for RRI:

Researcher 1: But the question is: is the solution then to set aside time, we always talk about time here, right, as if this was something that we lose when we do something, but, but if it's part of the culture then it doesn't, then it immediately isn't a discussion of how many hours do use for it, but it's just part of the everyday thinking of how you do things, right?

Researcher 2: Yeah

Researcher 1: So...

Researcher 2: That's the culture...

Researcher 1: That's the culture, not the time, right?

Researcher 2: But we establish that culture, perhaps, you said that there is no incentives for doing that. I would rather than have my post docs or PhD students just do those extra

experiments rather than talk to these social scientist guys.

The authors of this report include this excerpt because it is quite representative also to our experience of discussing such topics within (and outside of) DLN. In what followed the excerpt, the researchers suggested that DLN could give additional funding to interdisciplinary PhDs and postdocs, for example, a few extra months of salary. With extra workhours on their hands the researchers would be able to thoroughly participate in RRI discussions as well as explore other research fields than their own. This idea was brought up by early-career and senior researchers in focus group discussions and in two individual interviews, and across the board it was perceived as a good, feasible idea that the centre could implement. In addition to providing an interesting suggestion for future funding, this discussion also provides an example of what we take to be a general observation, namely that many researchers within DLN are well aware of RRI and actively relate to RRI.

More generally, the development of a common language in research projects that consist of scientists from different disciplines was described as challenging and time-consuming for the participants. In the scientists' accounts, time plays a crucial part in building up new interdisciplinary research groups that communicate well, which suggests that long-term funding is one of the most efficient ways of ensuring well-functioning collaboration. Funding bodies might therefore consider granting long-term funding in order to facilitate interdisciplinary collaboration. The value of having a highly active DLN Research School should also be remembered. As mentioned above, Hesjedal's research (forthcoming) indicates that early-career DLN researchers have invested effort into DLNRS activities and achieved a sense of community and developed a common identity there. A research school and especially the training part of the Ph.D., is in this sense a source of the time needed to develop a common language across disciplines and sub-fields.

Conclusions and recommendations

Discussing the topic of transdisciplinarity and other kinds of collaborations is not straightforward. The concept of collaboration tends to be laden with a positive value in itself: collaboration is "good" and something that will lead to a better outcome when compared to non-collaboration. Arguably, transdisciplinarity in each of its scholarly definitions is a more ambitious form of collaboration than interdisciplinarity, which again is more ambitious than multidisciplinary. The perceived "goodness" of collaboration may then be taken to mean that trans- is "better" than inter-, and so on.

As will be clear from this report, its authors do not subscribe to such a view. No type or mode of collaboration is good in itself. Its place and value depend on its goal and purpose. For some purposes, a narrow monodisciplinary research project is to be preferred.

We have described how the original Digital Life initiative from the Research Council of Norway identified several problems, challenges, and purposes for Digital Life:

- A. Increased (monetary) **value creation** from Norwegian life science, contributing to the bioeconomy
- B. Contributions to solving grand **societal challenges**
- C. Contributions to making biotech innovation (more) **responsible**
- D. Catching up with international research trends of **digitalization** and **convergence** between "wet/soft" and hard/numerical natural sciences, and better analysis and utilisation of big data sets from experimental life sciences.

As noted above, the Digital Life initiative envisioned a unified solution, namely to increase, intensify and innovate modes of collaboration under the label of "transdisciplinarity", and the DLN centre was given considerable autonomy in figuring out how to implement it.

By and large in DLN, we have found (i) little evidence of knowledge or familiarity with academic concept of transdisciplinarity and (ii) little evidence of the modes of collaboration denoted by that concept. This does, however, not mean that the DLN initiative has not facilitated new scientific collaborations. We find both interdisciplinarity, RRI activities and discussions, some radical interdisciplinarity, and some research-industry collaboration in DLN. Indeed, if we revisit the list of challenges for which Digital Life was expected to produce the solution, it is evident that each of them were addressed in different and to some extent separate ways:

- A. Increased (monetary) **value creation** was promoted by initiatives for **research-industry collaboration** and facilitation of innovation processes.
- B. Grand **societal challenges** were pursued by thematic orientation of research **topics**.
- C. The challenge of making biotech innovation (more) **responsible** was addressed by inclusion of **RRI elements** in the activities.
- D. Better **convergence** and utilisation of big data sets was sought by **interdisciplinarity** and/or Mode 2 research and **infrastructure** activities.

One could say that the Centre for Digital Life Norway addressed all the problems for which the Digital Life initiative prescribed transdisciplinarity as the solution, but mostly without becoming transdisciplinary. Assessing its success in doing so, is beyond the scope of this report.

Does this mean that the concept of transdisciplinarity is superfluous and has little to offer? We do not think so. Returning to our exposition below, one can recall that the concept goes **beyond common sense** and business-as-usual. The concept is radical in that it proposes new forms of production of knowledge that integrate experiential knowledge of non-academic actors and/or dissolve borders between disciplines to make for more relevant, usable, responsible knowledge. In this sense, transdisciplinarity can potentially contribute to all of the purposes A-D above. That seems to require, however, the

presence of actors with knowledge of and experience with transdisciplinarity, and a willingness in the DLN endeavour itself (including researchers, research organisations and the funder) to pursue it. It depends on what one wants to do.

Accordingly, our recommendations are conditional. We take it not to be our role to tell what DLN should do in its second funding period. That seems to be a task corresponding to DLN's various executive and governance bodies. We recommend:

1. To increase the awareness within DLN about the academic concepts of multi/inter/transdisciplinarity and their scholarly justification (for instance by disseminating and discussing this report), and to make terminology within the centre more uniform in this regard. In particular, we recommend to distinguish between inter- and trans-disciplinary.
2. To be mindful and take measures to meet the challenges and unintended consequences related to the scientific organisation of interdisciplinary research projects. We see this as particularly important for early-career researchers.
3. To make a conscious choice about the meaning and role of transdisciplinarity in DLN. This seems to call for answering the two questions that we do not pursue in this report, namely whether there actually is transdisciplinary research going on in DLN, and if DLN needs to develop more towards transdisciplinary collaborations.
4. Depending on the choice in point 3, actions should be identified and carried out to that purpose. Required expertise is likely to be called for, as would more non-academic actors, not merely as stakeholders but as knowledge holders.

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