Towards a Transdisciplinary Evaluation Framework for Mobile Cross-Border Government Services

Gregor Eibl[1(✉)], Lucy Temple[1], Rachelle Sellung[2], Stefan Dedovic[3], Art Alishani[3], and Carsten Schmidt[3]

[1] University for Continuing Education Krems, 3500 Krems, Austria
gregor.eibl@donau-uni.ac.at
[2] Fraunhofer Institute for Industrial Engineering, Nobelstraße 12, 70569 Stuttgart, Germany
[3] Johan Skytte Institute for Political Studies, University of Tartu, Lossi 36, 51003 Tartu, Estonia

Abstract. The evaluation and assessment of project results and their impact are still a recurring challenge in the digital government discipline. Many technologically driven projects or products have faced challenges, where the technology is advanced, but the market adoption and user acceptance are still lacking. To counter these challenges, this paper presents a transdisciplinary evaluation framework and how it could be applied. The foundation for the evaluation framework was a literature review on the most recent and relevant academic publications on transdisciplinary evaluations, which was narrowed down by using selected relevant search terms. This theoretical background was enhanced by a series of practical workshops to validate the findings. By using a transdisciplinary approach, this paper presents a transdisciplinary evaluation framework that enhances the evaluation process of project results in the digital government discipline with six pillars to reflect (1) the real word context, (2) interdisciplinary research, (3) going beyond science, (4) interaction (5) integration, and (6) relevance. Alongside these pillars, dimensions of measurement for the evaluation are also presented and elaborated on. While this evaluation framework could be adopted for many types of projects or products, this paper showcases how it is applied for an international digital government pilot research project throughout its development process. It presents the methodology and process used in establishing the evaluation framework, the evaluation framework itself, and a short discussion.

Keywords: Transdisciplinary research · Evaluation · Assessment · Research evaluation framework · Digital single market · Cross-border · Digital government · Sustainability

1 Introduction

The digital transformation landscape of European public administrations is evolving and capturing interest from various stakeholders. The share of projects that support a digital transition has grown, the scope of digital government research has expanded, new

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legislative and regulatory frameworks are being introduced, and public administrations continue exploring new opportunities that digitalization offers [1, 2]. While digital government is a relatively new research field, it derives knowledge from several established disciplines, and it includes elements of both practice and academia [3]. This is largely due to the nature of the problems that digital government research addresses. It often requires solutions that extend beyond a single research discipline [2] to support further improvements in how public administrations are governed [4]. For this reason, developing new knowledge and innovative solutions demands collaborative engagements between academic and non-academic actors who possess contextual knowledge and unique expertise to address the problems at hand. This requires projects encompassing diverse disciplines and a taking a transdisciplinary approach to creating spaces where science, policy, and industry can meet to address issues.

Transdisciplinarity is a complex concept adopted to address knowledge fragmentation by linking intellectual frameworks or disciplines initially separated from each other [2]. The outcome is often a new transdisciplinary field with its own conceptual structure [2]. Transdisciplinary projects focus on real-world and wicked problems, tackle issues in an interdisciplinary manner, extend beyond science, include various heterogeneous stakeholders, and integrate everyone's knowledge to enhance relevance for the active stakeholders but also society as the recipient. By nature, digital government projects are often transdisciplinary or have transdisciplinary elements [5]. They draw on knowledge and experiences from different research domains, including public administration, information systems, and computer sciences [2]. In the digital government domain, transdisciplinary projects are beneficial for complex undertakings, where the goal is to support different technological or governance changes [6]. However, implementing these types of projects is not an easy endeavour. They require different interactions between law and technology [7], bring together different kinds of expertise and often deploy artefacts that deliver real impact on public administrations. The design of activities and artefacts often occurs after complex negotiations and compromises between different views, interests, strategies, values, and regulations. For this reason, the implementation of transdisciplinary projects needs to be carefully monitored and evaluated against the expected impact and the attainment of the planned objectives.

In the digital government discipline, one of the challenging areas remains the evaluation and assessment of project results and the impact that initiatives deliver [8, 9].

The transdisciplinary nature of digital government projects could be noted as one of the causes, especially when establishing rules in assessing and evaluating the actual value that existing projects deliver. Evaluation becomes even more challenging if there is a discrepancy in how the value delivered by a project is understood in public sector-led initiatives against those led by the private sector [10]. Furthermore, according to Sellung and Rossnagel [11], when different disciplines are included in the evaluation stages, it becomes challenging to provide well-rounded evaluations. Especially in complex research projects.

Currently, in the research there are existing several evaluation frameworks that have been presented to measure the societal impact of transdisciplinary projects (e.g., [12–14]), yet there is still no unique way to include the different views of all stakeholders,

i.e., research and practice, into the evaluation of a transdisciplinary project (see [14–16]). This research gap, is in line with the practical Horizon 2020 and Large-Scale Pilots (LSP), which involvement of various disciplines in a project causes critical issues for researchers and practitioners to assess and evaluate the successfulness of a project [10]. This mainly occurs due to unfamiliarity with the evaluation techniques [17] and most likely the lack of a transdisciplinary evaluation framework for digital government projects. Thus, a custom approach, based on project particularities, needs to be co-developed by the stakeholders, considering the particularities of the desired impact, i.e., in the case of our project, the three pilots. Furthermore, there is little guidance concerning how to design an appropriate evaluation strategy [18]. Based on this research gap our objective is following.

The objective of this paper is to provide researchers and practitioners involved in digital government transdisciplinary projects with an explanation of the process followed through for developing an evaluation framework in addition to providing evaluation framework a transdisciplinary aspect. This study also develops an evaluation framework that not only provides essential information on how to evaluate and design the pilots, but also important aspects concerning the cooperation of partners, their exchange, and knowledge integration throughout the project. Thus, the research question we aim to answer in this paper is *how to develop an evaluation framework that is suitable for transdisciplinary digital government projects*?

In this paper, we present the digital government field as a transdisciplinary domain and provide an evaluation framework for digital government transdisciplinary research projects, in addition to the description of the methods used in the development of this evaluation framework.

The rest of this article is structured as follows. Section 2 provides a practical background overview and shapes the context for this study. Section 3 breaks down the processes and methods that were used to collect the data and conduct this study. Section 4 presents the key findings from the structured literature review and introduces the transdisciplinary framework for evaluating digital government pilots. Section 5 demonstrates the implications of this study and suggests areas for future research. Section 6 summarizes the key findings from this study.

2 Practical Background

The Digital Single Market (DSM) is a key element of the European Single Market that is grounded on the four pillars of free movement for goods, services, capital, and people between the Member States. The approach was always focussed on services that fosters the development of the Single Market. The Single Market began in the mid- 20th century with collaboration in coal and steel. By the end of the century the European Commission (EC) and the Member States had come to recognize the importance of fostering technological and digital development. Consequently, this has led to the preparation of new online services. The implementation of these new services was accompanied by several political steps.

The first step was the implementation of Directive 1999/93/EC on a Community framework for electronic signatures. The EC continued this by supporting electronic

and online services through the instruments of so-called action plans, the "eEurope 2002 Action Plan" and the "eEurope 2005 Action Plan" [19, 20]. Their main aim was to strengthen the digital infrastructure in Europe and to increase the digital skills of the potential users. A next step was the 'i2010 digital government Action Plan' of 2005. The way for the DSM was further paved by activities of the EC and the Council of the European Union, which issued further action plans and ministerial declarations. The 2009 'Malmö Declaration' and the 2010 'Digital Agenda' were essential to further pushing the digitization of the EU [21]. The eIDAS Regulation, established in 2014, was a key objective of the '2011–2015 digital government Action Plan', replacing the 'Electronic Signature Directive' by incorporating citizen identification, electronic seals and thus providing a European framework for accepting and using foreign digital identities for citizens and businesses in cross-border digital government services [22, 23]. The 'Tallinn Declaration' in 2017 and the 'eGoverment Action Plan 2016–2020' encouraged the ongoing implementation of the DSM [24]. These strategies and policy action plans required market transition by EU and EEA countries.

The transition of the common market of 28 Member States into a digital market is a very complex undertaking for which no blueprint existed. To showcase its technical feasibility on the one hand and to gather policy input on the other, the EC has started an initiative of so-called Large-Scale Pilot Projects (LSP) [25].

The EC has defined LSPs as targeted, goal-driven initiatives that propose approaches to specific real-life challenges (e.g., administrative, societal, or industrial). Pilots are autonomous entities that involve stakeholders from several sides. The focus is set on a European and national level. The supply and the demand side are covered, and contain all the technological and innovation elements, the tasks related to the use, application and deployment as well as the development, testing and integration activities [26]. To co-finance the LSPs the EC, with the consent of the Member States, has setup, beginning in 2007, several financial frameworks. The first one was the ICT Policy Support Programme (ICT PSP) as part of the Competitiveness and Innovation Framework Programme (CIP) that lasted until 2013. It was followed by the Horizon 2020 research and innovation funding programme from 2014–2020. As already mentioned, these projects involve multiple stakeholders with transdisciplinary approaches and aim to solve real-life challenges; they also require a coherent assessment of the project and project success.

For all LSPs and especially Horizon 2020 projects, evaluation of pilots is required as a requisite project deliverable, leading to the creation of multiple context-specific evaluation frameworks for each project and pilot. Until now, a coherent, generic, and extensible framework for the evaluation is still missing. These evaluation approach differences can also be seen in deliverables submitted by projects, such as DesignScapes, MAZi, ReFLow, and WeCount. Therefore, an ongoing LSP should be used as a nucleus for the development of a transdisciplinary evaluation framework. The mGov4EU project is on the one side a testbed for the technical approaches and the other side provides the frame and basis for this research. It is an undertaking that is driven by its members and originates from five European Member States. It will lift cross-border services supported by the Single Digital Gateway Regulation (SDGR) and by the eIDAS Regulation to new levels by enabling them for a mobile-device use we naturally expect nowadays

[27]. This will come with unprecedented user journeys by making extensive use of automatic attribute provision and SDGR's once-only principle, complemented by mobile identification so that the so-far cumbersome filling in of complex forms gets replaced by user-controlled and user-consented releasing of authoritative data. The project will, therefore, research, design, implement, and evaluate an open ecosystem for secure mobile government services to be used across Europe and beyond. This is accomplished by combining and enhancing the existing eIDAS layer and SDGR layer with modules for mobile devices that are generic enough that they can be reused in the emerging and thus still heterogeneous European mobile-government landscape. Thus, the project will provide a trustworthy federation of collaborative platforms. The outcomes of the project, software and architecture will facilitate the co-delivery, reuse, and trustworthy provision of accessible and easy-to-use public services. The project will implement the core once-only, digital-by-default, and mobile-first principles in a user-centric and user-friendly manner [28].

The results of mGov4EU project will be validated by multiple pilots implementing the enhanced infrastructure services for internet voting, smart mobility, and mobile signing. A key aspect of the pilots is the reuse of existing technical building blocks. It aims to integrate the solutions in day-to-day business and activities around the life-situations of the citizens where they use their mobile phones, to showcase that this is the key to a true cross-border, pan European public service provision [29].

The results (tangible and intangible) of the project will be content agnostic, reusable and extensible solutions [30]. They will provide several options for evaluating the outcomes.

3 Method and Process

This section describes the methodology and processes used in establishing the transdisciplinary evaluation approach. There are two main factors that were used as a basis for this multi-method qualitative research. The first is a literature review, which serves as a foundation and consisted of desk research on various elements of transdisciplinary evaluation frameworks. This presents the inductive coding methodology that was used in conducting the desk research that led to establishing the foundation of how, what, and why this type of evaluation is used and performed. The second factor was a series of workshops that were conducted and provided practical feedback to ensure a common understanding, requirements, and objectives for the evaluation. This allows the evaluation to be continuous throughout the development process, following an action based design science research, by seeking to develop scientific knowledge while solving the lack of a sufficient transdisciplinary evaluation approach [31].

3.1 Literature Review

To establish a foundation and to design our transdisciplinary evaluation framework, a thorough literature search was conducted, seeking the most recent and relevant academic publications on transdisciplinary evaluations. Due to transdisciplinarity being an interdisciplinary field of study, the search for the publications was conducted in two of the

largest peer-reviewed literature databases: Scopus and Web of Science. The search string that was used to conduct the search has as a starting point transdisciplinarity as it is at the core of the framework and includes the following:

> TITLE-ABS-KEY ((transdisciplin* AND (framework OR model) AND (evaluation OR benchmark* OR assessment))).

This way publications that focused on transdisciplinary frameworks or evaluations could be found. The search resulted in 806 results in Scopus and 631 in Web of Science. These were further filtered to those papers available in English, reducing the starting amount to 776 and 605 respectively, a total of 1381. After duplicates were removed, the search revealed 1006 papers. To be able to narrow down the number of publications by filtering those that were deemed unsuitable for the topic at hand, two researchers conducted a deep review of the title and abstract of the list of publications, removing publications for the following criteria: Duplicates that had not been detected before; Publications that were too specific: Focus on the field of medicine, Veterinary, ecology; Not a publication on transdisciplinary evaluation; Lack of indicators or relative sources of information for the goal of this desk research.

The sample was narrowed down to 185 publications, and finally, a conjoint examination with three researchers discussing those articles that were slightly unclear if they should be included in the analysis or not, brought the final sample down to 75. Out of these, 73 were available for download and were further reviewed and explored in their entirety.

To be able to move forward with the analysis, MAXQDA was selected as the software for coding the literature. An inductive approach was selected as the best option for this research, where a coding schema was defined after a sample of the literature was reviewed. First, three researchers reviewed and coded the same five papers that were deemed highly relevant when screening the databases. Next, a workshop with the academic researchers was set up to discuss the individually found codes and sub-codes for segments to understand transdisciplinarity at its core and how to evaluate it. A final set of codes and sub-codes were defined, alongside guiding principles on how to select a specific code for a segment. The rest of the papers were divided equally into the three partner organizations participating in the design of the evaluation framework. A total of 1375 segments were extracted in the texts and the categories in which they were coded are the following:

- Characteristics of transdisciplinarity
- Frameworks
- Dimensions

  – Purpose
  – Timing
  – Scope
  – Actors
  – Impact
  – Mix/Granularity

- Indicators
- Challenges of transdisciplinary evaluation

3.2 Workshops

Another goal of this methodology was to create an evaluation framework that included not only a sound theoretical background, but also a practical foundation. To accomplish this, workshops were conducted to tailor the evaluation framework to meet and set realistic expectations, requirements, and objectives for the pilot project. While this evaluation framework is being applied to a research pilot project, this evaluation framework could also be applied to other artefacts or types of digital government research projects.

There were two types of workshops: the initial alignment workshop and a series of pilot workshops. The initial alignment workshop took place with all the project partners involved in the evaluation of the project in an online environment. This included three scientific partners of various disciplines, and an industry partner belonging to the digital services and electronic voting field. These moderated discussions led to a common understanding of the roles of the partners, a first draft of expectations.

Following the alignment workshop, a series of three pilot tailored workshops were conducted. The knowledge and know-how gained from the literature review and the initial workshop established a foundation for the framework. Next, the scientific partners conducted and moderated the pilot workshop, as this was the focal point of this project. This workshop was divided into a series of phases. The first two phases were conducted in a hybrid setting, with most partners working face to face whilst some were present online. A total of 16 participants attended the workshop in situ, and 10 participated virtually. The workshops included all partners from the mGov4EU consortium, therefore there were partners with scientific focus, focused both on the eGovernment and identity disciplines, to economics, information science and social sciences, technical specialises with a focus on software development, legal specialists and govtech companies. The first of the series focused on pilot leaders answering the "5 Ws" [32] in order to provide the scientific partners with a current state of the pilot definitions. These questions refer to: i) what the pilots are about; ii) why the pilots are necessary iii) when and iv) where they are going to happen; and v) who is going to be involved and targeted respectively. In the subsequent second phase, the project partners guided by the pilot leaders were asked to elaborate on potential, pilot-specific indicators, which could either be provided by the indicators defined in the transdisciplinary evaluation framework or derived by the pilot development and design. The third and fourth phases of the workshop were continued online by all the relevant project partners. During the third phase, the participants separated the jointly developed indicators into two categories, i.e., related to the design process of the pilots, and the implementation itself. In case of a high number of indicators, participants were also requested to prioritize the indicators. In the final phase, the pilot specific groups were asked to reflect on how to measure each indicator, where information for the assessment and analysis could be found, and if the indicator could be a generic one, applied to all pilots, and not just one. Moreover, the groups were asked for approval and agreement on all the indicators established.

4 Transdisciplinary Evaluation Framework

Often a broader conceptual framework is needed as traditional bibliometrics for evaluation are insufficient for transdisciplinary projects [33, 34]. Defining a conceptual evaluation framework may involve not only searching through existing literature but consulting with experts, practitioners, and experienced stakeholders in a variety of fields [34]. By having a transdisciplinary evaluation framework, it aims to elevate interdisciplinary evaluation frameworks. The transdisciplinary evaluation framework aims at providing a comprehensive method to ensure that technical solutions developed in research (or other) projects meet needs required for market adoption and societal success. It does this by elevating interdisciplinary evaluation methods by including context on how to integrate a real-world viewpoint of the solution to create a solution that is 'beyond science'. In addition, it involves interdisciplinary perspective through relevant stakeholders and creating an environment that encourages interaction between those stakeholders throughout the entirety of the development process and integration to help ensure relevance.

As discussed previously, the research findings were extracted through a thorough literature analysis of scientific publications, and a series of workshops conducted to present the desk research results and have a common understanding of the requirements and objectives of a transdisciplinary evaluation. This section will present the six main pillars of the transdisciplinary evaluation framework, (1) real-world context, (2) interdisciplinarity, (3) beyond science, (4) interaction, (5) integration, and finally (6) relevance. An overview of each pillar will be presented, which will additionally showcase how the framework can be applied in a digital government project, and some possible indicators to consider. Indicators help aggregate information, allowing for the analysis of complex issues and adding value to thus help decision-makers make a suitable decision [35]. The second subsection will present some key measurement dimensions to be considered when applying the framework.

4.1 The Six Pillars of the Transdisciplinary Evaluation Framework

As a result of the literature analysis, there are six main pillars of transdisciplinary research to be highlighted, which in turn stand as the foundation for the transdisciplinary evaluation framework. Transdisciplinary research is embedded in a real-world problem context, is tackled in an interdisciplinary way, extending beyond science stakeholders, is done together in an interactive joint engagement by making sure that everyone's knowledge is integrated and transferred to enhance relevance for the active stakeholders, but also society as the recipient (See Fig. 1). All six pillars will be explored further below. Figure 1. Depicts how the six pillars interact with each other.

Real-World Context

The first pillar of the evaluation framework is the real-world context. At the beginning of transdisciplinary research, there is a problem of everyday life that needs to be solved [35]. For practitioners, it is of particular importance that the solution to an everyday life problem is addressed. These everyday life problems are examined to shape real processes. In addition, legal frameworks and possible actions have to be considered in their context [35]. In other words, transdisciplinary research focuses on solving real and

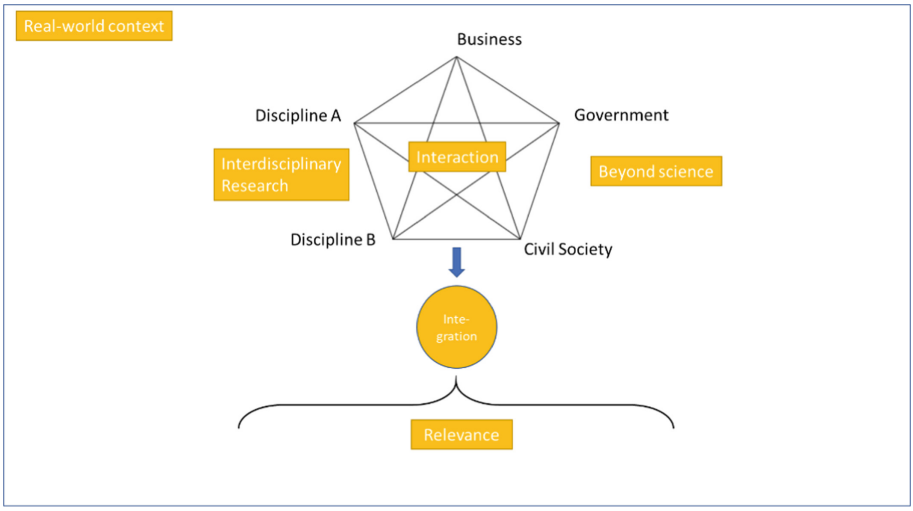

Fig. 1. Six pillars of transdisciplinary research

complex problems and questions aiming at creating knowledge that is solution-oriented to societally-relevant problems [36, 37]. Also, other authors [38] consider this problem – and the solution approach essential for transdisciplinary research. Its knowledge emerges from a particular context of an application by addressing societally-relevant problems as drivers for posing scientific research questions [39]. As shown in Fig. 1, the real-world context is represented by the grey rectangle, encompassing all the other pillars, as it is the starting point, the root of the transdisciplinary process. Some of the indicators associated to the real-world context, found in the literature, are that the research must manifest itself in actual practice and should meet policy interests [40].

On that note, when applying the evaluation framework to our project, the real-world context can be described as the backdrop and goal of the project pilots, implementing and validating enhanced infrastructure services for electronic voting, smart mobility and mobile signing. The project and the pilots have as a goal to leverage the SDGR and eIDAS together for mobile-device usage, pushing forward the practical use of inclusive mobile government services in Europe.

Interdisciplinarity

Interdisciplinarity is another key pillar of this evaluation framework. Transdisciplinary research includes interdisciplinary research, where transdisciplinary is the broader term for both concepts. The main purpose of transdisciplinary research is to search for solutions to a matter or a complex problem that cannot be solved with knowledge and techniques from a single discipline [36]. In other terms, it frees itself from its specialized or disciplinary boundaries, defining and solving its problems independently of disciplines. This is not to dismiss specialized and disciplinary knowledge, but to ensure that problems are not seen in a one-dimensional way, i.e., from a solely specialized or disciplinary perspective [39]. Interdisciplinary research includes considering the context of multiple disciplines and their intrinsic knowledge gathered in the same environment through

disciplinary transcendence and transgression [36], adding perspectives from different disciplines [37]. This requires researchers of different disciplines to work jointly [35] and to collaborate [41]. Therefore, an indicator is exactly that, measuring the number of fields involved in a project and if members have a variety of degrees [36].

Interdisciplinarity in Fig. 1 is represented by the variety of disciplines. When applied to our project, interdisciplinarity is present in the wide array of experts and internal stakeholders participating in the research, design, implementation and evaluation of the project and pilots. For example, the internal stakeholders working on the project cover a wide range of disciplines by incorporating social scientists, legal experts, socio-economic researchers, industry partners and technical specialists who work together to develop the needed infrastructure for the pilots. An array of interdisciplinary internal project stakeholders provides a wide understanding of the existing best practices available, the limitations in existing software, and helps to find ways to complement each other, providing their strengths to be able to achieve a sturdy solution for cross-border mobile government services. In addition, there is an external stakeholder board that serves as another opportunity to involve disciplines or perspectives that are still needed.

Beyond Science

Another important aspect of the transdisciplinary evaluation is its bridging function between science and practice, transcending the boundaries between scientific disciplines and societal actors, understanding that a project must go beyond just science [38, 39]. The involvement of various non-academic stakeholders is an essential characteristic of transdisciplinary research projects [35], which can span everything from business or government to civil society, or from industry to societal entities, seeking application of the research results [36].

First, societal problems have to be related to scientific problems [42] so that researchers can work jointly with practical experts [35] on an equal basis [37] involving scientific and non-scientific sources or practices [43]. This alignment of partners' needs and desires makes the process relevant to all parties [44], contributes to both societal and scientific progress, accounts for the diversity of perspectives [39], and can create a culture of accountability [36]. Stakeholders need to feel heard, represented and somehow trust researchers to take into consideration their input [37, 45–47]. It is important for project leaders to facilitate the collaboration process[48], which is a complex undertaking and requires assessments of who should be involved in designing for almost all citizens, how many stakeholders are needed, who decides what should be a goal for a design initiative, and on what basis and legitimacy [49] As shown in Fig. 1, the beyond science pillar is represented by the parties interacting with the disciplines, such as businesses, governments and civil society. A relevant indicator would be to identify if there is interaction between academia, productive sector and society and if there is participation by extra-academic professionals [36].

The beyond science pillar is present in the project not only in the core consortium of the project, which includes academics in the fields of digital government, iVoting, transdisciplinary and technical skills, but also includes industry and businesses with expertise in iVoting systems and digital government services provision. Moreover, external stakeholders are consulted both from private enterprises and government. The key external stakeholders are represented in an External Stakeholder Board for the project, which

holds workshops and opportunities for exchange throughout the project to incorporate their insights into the project as it develops.

Interaction

Interaction is the third main pillar of transdisciplinarity, as already mentioned, with very different actors from different disciplines and beyond the scientific field work together in a transdisciplinary project. In many definitions and descriptions of transdisciplinary research, this interaction is emphasized and referred to in different ways. The term co-production is considered a core concept of transdisciplinary research, representing the importance of interaction between the stakeholders [36]. Others emphasize the notion of research collaboration [37, 39], or the cooperation of different algorithms and approaches [43]. The goal is to connect skills and knowledge through teamwork and collaborative networks [36], cooperative learning and problem solving [43], active participation of all stakeholders [35], and engaged participants in processes of reflection, deliberation, and negotiation [41]. Interaction is depicted in Fig. 1 by the lines connecting the different stakeholders, the disciplines, and the private and public representatives. A suitable indicator refers to the amount and frequency of participatory events and networks created and/or expanded throughout the process [41].

Since the beginning of our project, interaction has been key to the development and progress of the project. Regular meetings are held between the consortium partners and joint work has been produced between the academics and industry members. Also, a series of workshops have been key to the understanding of different topics to further design the pilots. The interaction with the external stakeholders began almost simultaneously with the project start when interviews were conducted with government experts and public servants to establish the need's elicitation of the pilots and project context. Interaction is a key role in exchanging, gaining, and generating knowledge that will be further incorporated in the integration pillar throughout the development of the project.

Integration

Given the purpose of the above-described interaction, terms such as integration, synthesis, or transition are mentioned. Transdisciplinary research seeks to overcome the fragmented view of science and hyper-specialization through dialogue and integration of knowledge [36]. Integration is the fourth pillar of transdisciplinary evaluations. Integration is the cognitive operation of establishing a new, previously non-existent connection between the distinct epistemic, socio–organizational, and communicative entities that make up the given problem context [39]. Thus, it produces new knowledge by integrating these different scientific and extra-scientific findings [42], which others refer to as synthesis of the individual findings [37]. While the term integration implies the integration of disparate entities into a new entity, others emphasize the term transition, which refers to the successful solutions or applications to a distinct application domain [43]. In Fig. 1, integration is represented as the sum of the stakeholder's interaction, the outcomes, results and learning of this process. Indicators associated to this pillar are changes in attitude of participants, new insights and learning processes and new scientific knowledge gained [37, 50].

Within the project, integration is the continuous learning and improvement of processes, adapting of goals and development of solutions brought forward by the constant

interaction between internal and external stakeholders. The workshop results, interview analysis and working meetings sum up the valuable outcomes of the interaction.

Relevance

Finally, the last pillar of transdisciplinary evaluations is the relevance. The promises of transdisciplinary research can be divided into benefits for project members (internal) and benefits for external stakeholders (external). Within the project boundaries, the most fruitful engagements will occur in environments and partnerships that provide mutually beneficial and relevant learning opportunities for both users and researchers [44]. Mutual learnings should be facilitated in successful transdisciplinary projects [37]. Other internal effects besides shared learning include mutual accountability, ownership, and leadership among project participants [41]. Outside the project boundaries, transdisciplinary research contributes to both societal and scientific progress [39, 42], which is guaranteed by the broad stakeholder engagement beyond science, mentioned above. In turn, other authors emphasize the practical benefits to society, e.g. by initiating public health programs, generating land-use plans, developing environmental policies, and excluding some of the standard academic outputs such as peer-reviewed publications or academic journals [41] or stress the need to secure the promised societal benefits [37].The final pillar of the transdisciplinary evaluation framework is depicted in Fig. 1., as the final overarching outcome, the final bracket. The relevance of transdisciplinary research can be linked to indicators such as existing changes in practice, new institutional frameworks created, and decisions made [37].

When inserting the framework in the project, relevance sums up all the aforementioned pillars that have shaped the design and development of the pilots. These pilots have the relevance of addressing the real-world context and promote the development of cross-border mobile services to the end users. Ideally, the relevance will facilitate market acceptance and sustainable success of the project beyond the project timeframe and results.

Overall, transdisciplinary research aims to provide a fundamental understanding [35] to generate knowledge that is solution-oriented, socially robust, and is transferable to both scientific and societal practice [39]. The above-mentioned pillars are six core aspects project evaluators must consider when delineating and designing their evaluation process, making sure all parts are addressed throughout the project. Embedding the framework within the project allows for a deeper understanding of how the framework can be used in future projects. To summarize, the real-world context is depicted as the main goal the pilots and project are trying to address within the EU digital government field. Interdisciplinarity is present in the variety of disciplines represented by the different consortium partners experts in the academic, legal and industry fields. Moreover, the beyond science pillar is present with the internal and external stakeholders involved in the project throughout the interaction in the form of interviews, meetings, and workshops. The integration pillar is the valuable results and input received through the interaction process of the project. Finally, the relevance pillar reflects the constant improvement and steps throughout the development process and how all the pillars have impacted and shaped the overall outcome and its relevance.

In the following subsection the dimensions of measurement of transdisciplinary evaluations will be discussed.

4.2 Dimensions of Measurement for Evaluation

The term "evaluation" can be described as "the systematic collection of information about the activities, characteristics, and outcomes of projects" that aims to assess the achievement of the objectives, the efficiency, effectiveness, impact, and sustainability of a plan [17]. The formative evaluation of the engagement process and its impacts, including demonstration of the success of both process and outcomes is essential [22]. In this context, activities can be seen as actions performed by the project, leading to output generated by the project. They steer outcomes, which are changes in knowledge, attitudes, skills, and relationships, manifested as changes in behaviour. These changes, which are changes resulting wholly or in part from a chain of events to which the project has contributed, finally create impact [23].

Below, we summarise the five major dimensions of measurement that were identified during the literature review process. These serve as a guiding tool for evaluators, each of these dimensions can dictate one or several indicators, process timings and process steps within the evaluation framework and the corresponding pillars.

The first dimension concerns the overall purpose of the evaluation; it has been proposed that a differentiation be made according to the following categories: accountability, strategy, broader purposes like learning and marketing, or multiple purposes [51]. In addition, it was suggested to make the evaluation on the basis of the following four principles: relevance, credibility, legitimacy, and effectiveness [45].

Another possible dimension is the timing, which can be separated into ex-ante, ongoing, ex-post, ex-ante + ex-post, or interactive [46]. In terms of general evaluation phases, often authors refer to classical ex-ante and ex-post evaluations [38]. A long-time frame for evaluation may be required to evaluate the outcomes of an initiative as the consequences, contributions and long-term effects may appear gradually [33, 52]. Evaluating a project immediately may be skewed by the impressions of the recent activities in the project [12], but measuring the long-term contributions can also be a complicated task. Defining when to evaluate, and how, either in a continuous loop through multiple iterations [53], or at a single instance, is a key dimension to be considered when designing an evaluation.

The third dimension to highlight is the scope; assessments could be categorized into a single assessment of an individual object of analysis or performing a networking assessment, studying the interaction between linked groups or institutions [36]. Assessments can also span products, entire projects, or programs [42]. One possible distinction is what happens internally within a project and what happens externally primarily in the organizations of the stakeholders, but also within society [54]. Transdisciplinary scientific collaboration can be evaluated on different scales ranging from proximal/micro to distal/macro levels of analysis [55].

Actors are a key dimension to be considered. During the evaluation, different actors can be identified. For example, the researchers conducting a study can also be the evaluators, or different persons can take over this role [12]. Another possibility to form an evaluation could be a coaching model, facilitating self-reflection about what members are supposed to be doing and how well they are doing it in comparison to a jury model [53]. One differentiation is how interdisciplinary teams integrate disparate bodies of

knowledge in 4 types: common group learning, modelling, negotiation among experts, and integration by a leader [38].

The impact of a project or activity is a key dimension to be measured, and usually the most well-known and adopted evaluation dimension throughout evaluation frameworks. Societal impacts of research projects range from direct impacts (e.g., knowledge generation) to long-term community impacts (e.g., community well-being) [12]. Another possibility can be found when following the principles of citizen science. The evaluation of engagement can be considered in three dimensions: (i) scientific impact; (ii) participant learning and empowerment; and (iii) impact on society at large [48] (See Fig. 2).

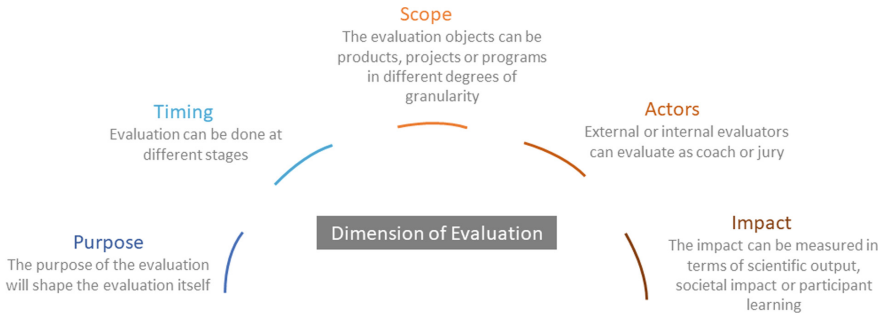

Fig. 2. Dimensions of evaluation

To summarize, we can see that purpose, timing, scope, involved actors, and impact are five measurable dimensions to focus on while creating an evaluation framework. Moreover, these are five recurring dimensions, but others might appear in a different project as each project is embedded in a particular context.

5 Discussion

This chapter discusses the main findings of our transdisciplinary evaluation research in comparison to other scientific work, surprising and unexpected results, the limitations of our findings and suggestions for further research.

Firstly, the evaluation framework presented above could be used in practice as a blueprint for adapting a context-specific framework to the needs of research projects. Most often evaluations of digital government research projects focus on evaluating functional requirements as stated in a deliverable usually produced at the beginning of a project. By utilizing the six pillars of the transdisciplinary evaluation framework, research evaluators will think beyond functional testing and include broader assessment criteria, which then increases the likelihood that the project results will be relevant in a real-world context.

Secondly, our findings make it clear that there exist a variety of different definitions of transdisciplinary research [52], many of which share the same characteristics. Thus, several authors come up with their own definition after reviewing existing ones [5, 19]. In

contrast to setting up our own definition, we distilled the main characteristics reoccurring in existing definitions throughout the literature, without formulating our own new one.

Thirdly, our results show that evaluation frameworks propose different dimensions for measurement [36, 56]. Knowledge of these dimensions helps to make informed decisions about evaluation needs in the development of a broader evaluation framework.

Moreover, each process needs to adapt to a specific context, the needs of both scientists and non-academic parties, and reach the desired outcomes, taking into account the limited amount of money and time [57]. Selecting the appropriate methods for collaboration, knowledge integration, and evaluation is important to accommodate each particular project's context [58]. This need of adaption to specific contexts underlines the importance of good process models for adapting evaluation frameworks.

Generally accepted methods suggested by evaluation frameworks are mostly missing. In scientific sources, the aspect of understanding dominates over action-oriented perspectives, while implementing agencies emphasize the need for collaborative action over a knowledge-oriented perspective [59]. Action design research emphasises the importance of building and evaluating ensemble artefacts in their organisational environment, which makes it possible to identify organisational paradoxes that are contradictions between interdependent elements [60]. A transdisciplinary evaluation framework should be broader in terms of the elements to be measured and go beyond the mere measurement of scientific contributions.

A surprising outcome of the pilot workshops was the participants' strong focus on indicators to assess the technical feasibility of the artefacts. After the participants had been presented with possible indicators from the literature review, a broader range of indicators was identified.

Limitations of this study include the missing test of the framework in different digital government projects. Future empirical research can build upon the present article by testing the proposed framework in different digital government projects. Within the remaining project duration this limitation should be addressed by applying the framework with the planned pilots. Outside the project, the case study research that follows the evaluation model also has the potential to further refine the model and identify specific challenges in other settings. Research that uses reliable and valid measures of processes and outcomes would be particularly helpful in testing the model and identifying appropriate improvements or extensions. Another limitation mainly lies in the short timeframe of this study. A long timeframe may be required to evaluate the outcomes of an initiative [33, 52] and it is difficult to capture the long-term contributions of activities that extend through several months or years [61]. As the technical artefacts prepared for the pilot projects are only produced later in the project, the first round of evaluation can only cover the evaluation of the design phase of the pilot projects. One advantage of a shorter timeframe is that participants will still be in the process of forming their opinion about the study [12].

The third limitation is the strong focus on transdisciplinary evaluation frameworks mentioned in Sect. 3.1, while much could be learned from research on the evaluation of interdisciplinary projects. Since the literature search already yielded 806 papers, the search was not extended beyond transdisciplinary evaluation frameworks. Future research could additionally build on the framework and propose a general set of indicators

that are in principle suitable for assessing transdisciplinary aspects. This general set of indicators could serve as an impetus for discussion on adapting the framework to the specific research projects.

6 Conclusion

Since digital government projects draw their knowledge from several established disciplines and include elements from both practice and academia, these projects have a strong transdisciplinary orientation, which translates into a challenging evaluation of project outcomes. Our guiding question was therefore how to develop an evaluation framework that is suitable for transdisciplinary digital government projects.

The developed framework builds on six pillars of transdisciplinary research, namely (1) real-world context, (2) interdisciplinary research, (3) interaction, (4) beyond academia, (5) integration, and (6) relevance, and proposes a few indicators from the literature grouped according to the six pillars as food for thought for adopting a context-specific evaluation framework. Furthermore, knowing possible dimensions will help in developing specific evaluation frameworks. It also shows an example of how this framework has been applied in a European Union research and innovation project under Horizon 2020.

Next, it is envisaged that the proposed model will be tested during the remainder of the project, which leaves open an important part of transdisciplinary research evaluation, namely capturing the long-term contributions of activities that go well beyond the project boundaries.

Future research could further elaborate this framework and develop the indicators from the literature into a more general set of indicators that, together with a process model for adoption, could form a blueprint for the context-specific development of transdisciplinary research evaluation frameworks. Incorporating a transdisciplinary approach that creates spaces where science, policy and industry can meet to address specific issues in digital governance projects, could go beyond this area and contribute to better market acceptance of newly developed technologies in general.

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