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# Proceedings of the Mini-Conference on Transdisciplinary Research and Design

# TRaD 2022

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(Eds.)

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# Proceedings of the Mini-Conference on Transdisciplinary Research and Design (TRaD 2022)

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Edited by

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# Transdisciplinary research and design – Editorial

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**Abstract**

This editorial summarizes the background and findings of the First Mini-Conference on Transdisciplinary Research and Design (TRaD 2022) held in Oulu. We describe the aim and vision of the conference, the conference theme, the articles presented and published in the conference proceedings, and the history of the research groups organizing the conference. Furthermore, in the editorial we highlight the main findings in relation to the conference aim. We discuss the conceptualization of transdisciplinarity and directions for further research and collaboration on this topic.

**Keywords**

Transdisciplinarity, transdisciplinary research, transdisciplinary design, transdisciplinary education, nexus analysis, human-computer interaction, human-centred design, HCI, design, STEAM, design-driven language education, diversity, participatory approach.

## 1. Introduction

The Mini-Conference on Transdisciplinary Research and Design (TRaD 2022) was organized on 14th February 2022 as an online event at the University of Oulu, Finland. This was an inaugural event gathering presenters and research presentations from a broad spectrum of disciplines: information systems, human-computer interaction, information technology, product development, environmental engineering, architecture, engineering, fashion design, language studies, and education.

The conference was arranged by the INTERACT Center for Transdisciplinary Research (https://interact.oulu.fi/ctr) in collaboration with EveLINE, a multidisciplinary research group at the University of Oulu (https://nexusunioulu.wordpress.com/people/). Over twenty years, the organizing groups have shared an interest in people's (inter)actions and agency in technology-rich everyday life, and transdisciplinary research.

The aim of the conference is to promote and advance the state of the art in transdisciplinary research. The conference vision is to bring together researchers from different academic fields to discuss and explore issues and questions related to experiences and understandings of transdisciplinary work in research, design, and education. We think TRaD 2022 was successful in accomplishing both the stated aim and vision with its contributions to the literature and the clarifications of transdisciplinarity during the live dialogue between participants. The conference included *five paper presentations* (which are highlighted and cited in this editorial), online discussions on the presented topics, and interactive annotations on the Padlet online tool. The participants included doctoral researchers, professors, senior researchers, lecturers, and practitioners from universities and companies in Finland, Germany, and the United Kingdom.

The conference started with an introductory talk by Professor Netta Iivari, head of the INTERACT Research Unit and the Center for Trandisciplinary Research. This was followed by a presentation by

Leena Kuure, Netta Iivari and Marianne Kinnula on transdisciplinary research conducted within EveLINE research group. The five paper presentations were grouped into two sessions. The first session started by a paper about transdisciplinary innovation and education through Science, Technology, Engineering, Arts and Mathematics (STEAM) (see **Durall et al., 2022**), and continued by a paper on mapping the divergent perspectives surrounding Finnish hydropower and its removal (see **Patro et al., 2022**). In the second session, the first paper considered transdisciplinarity in Human Computer Interaction (HCI) (see **Rajanen & Rajanen, 2022**), while the second paper discussed diversity in product teams presenting a discourses survey on the topic (see **Hekanaho, 2022**). The third paper addressed design-driven language teacher education as a transdisciplinary field (see **Kuure et al., 2022**).

The papers presented in the conference are included in this volume proceedings. Thus, the TRaD 2022 Proceedings comprise original short papers that have not been previously published elsewhere. The papers were selected for presentation in the conference through an open call for papers (see section 4). The papers were discussed by the participants during the conference sessions live in Zoom, through written annotations in Padlet, and in the final session by the conference organizers and participants. Conference organizers (i.e., the authors of this editorial) further reviewed the papers and provided written feedback and suggestions for the final versions.

## 2. History

The INTERACT Research Unit was established officially in 2015 as a research unit within the Faculty of Information Technology and Electrical Engineering (ITEE) of the University of Oulu, but it has a long history of operating as a research group inside the then Department of Information Processing Science (now the Degree programme of Information Processing Science). The INTERACT Research Unit provides research and education in human-centred design and digitalization. The research focuses on three strategic areas, namely, Politics of design, Digital transformation, and Usability and user experience. The research is positioned at the intersection of Information Systems (IS) and HCI. It involves a strong emphasis on Scandinavian values, and draws on qualitative, interpretive, critical, and participatory research methodologies. In recent years, the research has also started to pay attention to different kinds of societal issues, such as school bullying, through inclusive and empowering processes of design and making.

The Center for Transdisciplinary Research (CeT) was established by the INTERACT Research Unit in 2018 based on strong, multidisciplinary research collaboration for more than twenty years within the EveLINE research group at the University of Oulu. Aiming to strengthen and make this collaboration more visible and institutionalized, CeT focuses specifically on promoting transdisciplinary research and design to address the emerging global challenges of the increasingly digital world that we live in and shape through our participatory processes. CeT addresses two strategic focus areas of the University of Oulu: 1) digital solutions in sensing and interaction, and 2) understanding humans in change. As the transdisciplinary approach often means cross-boundary collaboration, it is challenging in itself. Therefore, the transdisciplinary approach requires discussion among participants to understand and transcend these various challenges. The CeT members are engaged in a broad range of activities to advance transdisciplinary research and design, e.g., organizing events (workshops, conferences, seminars), developing novel approaches and understandings, publishing research articles, carrying out research projects, and networking locally, nationally, and internationally.

One of the important threads in the emergence of CeT is EveLINE – a research group that launched its collaboration at the beginning of the 2000s along with the strong wave of digitalization in Finland. The group initiated its work in a virtual university project established to promote research guidance on all levels of university education as a joint venture of participants from different faculties. The work involved workshops on theoretical and methodological issues, online sprints in study circles, and discussing participants' thesis manuscripts in different phases of the research. After the two-year funding period, the collaboration was integrated in the daily work of the participants in academia and became more directly oriented to research. An important source in this work was an international "discourse nexus summer school" organized in 2004 by professors Paul McIlvenny and Pirkko Raudaskoski at Aalborg University, with guest speakers and facilitators including Prof. Ron Scollon

(Georgetown University, USA). Nexus analysis involving a mediated theory of social action and a participatory research strategy (Scollon, 2001; Scollon & Scollon, 2004) explored at that event among other topics was something that became a central theoretical and methodological framework binding researchers from various disciplines together. EveLINE was established as a research group in 2008, around the theme of everyday life in technology-rich neo-communities which started appearing as a central focus for projects and events of different kinds.

## 3. CeT and EveLINE approaches to transdisciplinarity

CeT and EveLINE approaches to transdisciplinarity heavily rely on nexus analysis, a research strategy and theoretical lens deriving inspiration from various disciplines and traditions, most notably linguistic and anthropological fields, including conversation analysis, critical discourse analysis, semiotics, multimodal discourse analysis, and ethnography, but also practice theories, and activity theory, among others (Scollon & de Saint-Georges, 2012). Nexus analysis, to start with, approaches phenomena in our everyday life as complex entanglements of social action and practices that evolve in situ but echo at the same time discourses across wider timescales – this suggests that examining nexus of practices requires a multiplicity of foci, methodologies, and theoretical perspectives – and therefore also expertise of different kinds combined for achieving a deeper and also holistic understanding of what is going on. Transdisciplinarity is required from single researchers, on one hand, to approach the complex phenomena they study with open eyes, acquiring more expertise and understanding from different fields. On the other hand, transdisciplinarity is needed by joining the expertise of researchers coming from different fields – and that, again, requires openness to detach themselves from their own familiar ways of doing research and entering progressive dialogue, exploring new approaches to understand the complex phenomena better and in new ways.

In EveLINE we have carried out studies on transdisciplinary research, design, and education (e.g. Iivari, 2019; Iivari & Kuure, submitted; Keisanen & Kuure, 2011; Kinnula et al. submitted; Kuure et al., 2016, 2020; Molin-Juustila et al., 2015). These studies emphasize complexities associated with transdisciplinary work, within which various kinds of histories, experiences and expertise become articulated, advocated, and acted upon, and where participants bring with their historical bodies diverse epistemologies, methodologies, values, practices and assumptions to the joint endeavour. Different kinds of relationships, alliances, interaction orders become established, enacted, and negotiated among the participants, with divergent discourses circulating around and shaping the joint endeavour. The institutional contexts that intersect in the collaboration both limit and open possibilities for the work, and influence the participants, who search for their zones of identification within their own institutional contexts as well as in relation to others. We call for critical reflection on our (transdisciplinary) research, design, and education practices: we should be reflecting on what kind of researchers, designers, and educators we are and what kind of associated practices and values we carry with us, advocate, and allow to speak through us.

## 4. What is transdisciplinary research, design, and education?

The idea of the *Mini-Conference on Transdisciplinary Research and Design (TRaD 2022)* was born from our wish to invite a broader community interested in the topic of transdisciplinarity to discuss and reflect on the topic with us. Our call for papers invited submissions based on *empirical studies or that provide theoretical and/or methodological discussion* on the conference theme. Papers which reflected on the *experiences* of doing transdisciplinary research were also welcome. In this first edition of the conference, we especially encouraged submissions addressing questions of the following kind:
- What is transdisciplinary research and/or design?
- What (novel) approaches are used?
- What challenges and/or good practices have been encountered?
- What notable results are there to learn from?

In addition to these topics, we also welcomed submissions that would discuss and explore research experiences and perspectives on any issues and questions relevant to advancing transdisciplinary research and design. Papers had to cite relevant published work and clearly indicate the importance of the submission to transdisciplinary research and design. Furthermore, the conference discussion also included reflections on transdisciplinary *education*, strengthening the transdisciplinarity of the University of Oulu, and brainstorming ways to collaboratively contribute to the state of the art on transdisciplinary research, design, and education.

In the following we summarize the results of the conference by shortly analysing the papers through the lenses of the call's questions.

## 4.1. TRaD insights on what transdisciplinary research, design and education mean

Transdisciplinarity seems to be a difficult concept to define. Different researchers view transdisciplinarity through their own experiences and many use the term without thinking of it deeply. It is easy to mix or interchange transdisciplinarity with multi-, inter- and cross-disciplinarity. A common view is that more than one discipline is involved, connected, and built upon, but how transdisciplinarity stands out from the other approaches and how it is performed are things that need to be clarified. In the following, we clarify the term based on the conference papers and discussions.

Mikko Rajanen and Dorina Rajanen in their paper "**Transdisciplinarity in HCI**" identify the origins of the term "transdisciplinary" back to Piaget in the 1970s (Nicolescu, 2005; Cole, 2019). The paper outlines and reflects upon the concepts of transdisciplinarity, HCI, and transdisciplinarity in HCI. Transdisciplinarity is different from multi-, cross-, and inter-disciplinarity in that it builds knowledge *beyond* the academic disciplines, *across* them, and *between* them (Nicolescu, 2014). Thus, transdisciplinarity is not confined within one or more disciplines but seeks to cover realities that are ontologically situated between the existing academic discourses, beyond them and across them. In the HCI field, transdisciplinarity is driven by the design-orientation of the field. The HCI field contributes with new designs to the socio-technical landscape and new realities are formed that need to be understood, integrated, and improved in all their complexities.

Epari Ritesh Patro, Outi Autti, Sahand Ghadimi, Jenni Hakovirta, Päivi Magga, Anu Soikkeli and Ali Torabi Haghighi in their paper "**Mapping the divergent perspectives surrounding Finnish hydropower and its removal**" view transdisciplinarity as offering sustainable solutions to problems that have multiple objectives of different nature that are defined by stakeholders with different backgrounds (e.g., "Dam removal is inherently transdisciplinary effort, multiple objectives are at stake and have to be addressed concurrently."). The transdisciplinary approach proposed in the paper builds upon and extends environmental engineering and architecture approaches to "better understand some of the conflicting viewpoints evident in discipline-based approaches of narratives over the implications of the hydropower dams."

Eva Durall, Claudia Carter and Kathryn Burns in their paper "**Transdisciplinary education and innovation through STEAM**" define transdisciplinarity by the following three main characteristics: Research addresses a realistic setting, deals with complex problems, and works across, between, and beyond disciplinary boundaries. Accordingly, transdisciplinarity breaks down disciplinary barriers "through reaching out to external knowledge (such as policy making and practice knowledge, or local and indigenous knowledge)."

Leena Kuure, Tiina Keisanen and Riikka Tumelius, discussing "**Design-driven language teacher education as a transdisciplinary field**", define transdisciplinarity as transcending traditional disciplinary boundaries. In the humanities involving technology-development for language education, transdisciplinarity often refers to envisioning and applying alternative ways of thinking, learning, and teaching. Furthermore, quoting Colpaert's (2018) definition, they characterize transdisciplinarity as the "ontological specification of knowledge constructs on a higher, boundary-transcending level of abstraction" (p. 485).

Finally, Minna Hekanaho in her paper "**Diversity in product teams – A discourses survey**" views transdisciplinarity as "uncovering knowledge that might otherwise fall between disciplines", a feature also identified in the other papers.

In summary, based on the proceedings of the conference, we can conclude the following about the nature and character of transdisciplinarity:

1. *Transdisciplinarity is an approach that is evolving as the result of new challenges in society and of the need to address these challenges*. For example, in HCI new designs and interactions with the increasingly digitalized environment require new approaches and thinking outside the boundaries of the disciplines that have traditionally built the theoretical and methodological foundation of the field. Similarly, researchers and practitioners in the fields of environmental engineering, design, language studies, educational sciences, and product development, encounter new challenges, conflicting views, complexities, and broad implications of their work that require new and transdisciplinary approaches.

2. *Transdisciplinarity builds knowledge beyond one or more academic disciplines, across them, and between them*. Thus, transdisciplinarity is not confined within one or more disciplines but seeks to cover realities that lie ontologically between existing academic discourses, beyond them and across them.

3. *Transdisciplinarity reaches external sources of knowledge outside of academic disciplines* (e.g., indigenous communities, alternative sources, arts, shared understandings). This relationship is bidirectional; transdisciplinarity benefits from and contributes to knowledge outside the academic domain. This means that researchers reach out beyond the academia when engaging in transdisciplinary research, but also that transdisciplinary research has the capacity to enable researchers to reach other areas of life (e.g., in comparison to inter- and multi-disciplinarity or just any field-specific research). Furthermore, by reaching out to other sources of knowledge, such as indigenous communities, the arts, alternative sources and shared understandings, we highlight the importance of participatory approaches to engage research participants ('outside of academic disciplines') to act as co-researchers and actively participate in creating new knowledge instead of being only objects of research.

4. *Transdisciplinarity defines and explores new theoretical and empirical constructs at higher levels of abstraction* (e.g., society, community, cultures, values) *and transcends existing disciplinary discourses* (for example, with innovative theoretical, empirical, technical, or methodological constructs).

## 4.2. TRaD insights on (novel) transdisciplinary approaches used

The five TRaD 2022 papers identify and discuss various approaches of how transdisciplinary work is carried out. These can be specific to their analysed context and level of analysis (i.e., HCI, environmental engineering and its social impact, language education, product development, higher education in science and arts) but can also be explored in other contexts in the future.

In the HCI context, Rajanen and Rajanen identify two approaches on transdisciplinarity: one that builds on *a theoretical, epistemological and axiomatic perspective of science*, and another that is operationalized at individual level, the so-called *polymath approach*. In the first approach, HCI is viewed as "having different layers of reality within the socio-technical context" whose dynamics can be observed and researched by crossing discipline boundaries. The polymath approach is related to education and, specifically in HCI higher education, aims at providing HCI students with "a wide variety of skills, experiences and expertise to create a holistic understanding" of the HCI practice and the socio-technical landscape and requirements.

When discussing hydropower rehabilitation and removal, Patro et al. identify both qualitative and quantitative approaches to gain understanding of the multiple views and objectives of the different stakeholders involved. *Participatory approaches* to involve local stakeholders in the specification of the local knowledge and requirements as well as *quantitative evaluation of multi-faceted decisions* are among the solutions explored by the research team.

Durall et al. parallel transdisciplinary education and innovation with STEAM approaches and discuss different strategies used in twelve cases where STEAM was implemented. Among the strategies used, they identify *framing* to allow participants to employ creative thinking, collaboration, and

participatory practices; *exploration* of new concepts and methods; *addressing real-world challenges*; and searching for and developing *innovations*.

In a language teacher education context, Kuure et al. address transdisciplinarity through the concept and practice of design-driven education. *Design-driven education* started as a project- or problem-based approach to language teacher education and was the result of collaboration with information technology and language technology companies, and university units in engineering, human-computer interaction and participatory design. Design-driven education implies that the learning process uses a design process model that includes stages starting from "problem-formulation, background research, ideation, concept generation and prototype preparation to experimentation with schools or other contexts for language learning".

In product development, Minna Hekanaho addresses the transdisciplinarity of development teams through *the concept of diversity*. Thus, the paper identifies a practical way to approach transdisciplinarity by including people with diverse backgrounds in a project. The paper critically analyses selected cases by utilizing a discourse lens to identify how diversity is recognized and utilized – or not.

## 4.3. TRaD insights on challenges and/or good practices encountered

All papers have identified challenges in addressing transdisciplinary research, design, and education such as complexity of the issues, conflicting views of different stakeholders, difficulty of collaboration between different stakeholders and practitioners, and urgency of acting and exploring solutions. Complexity is seen across the papers in the interleaved social, economic, technical, and ecological variables, actions, and impacts.

Good or promising practices have been identified in terms of *methods of analysis* (nexus analysis in the paper by Kuure et al.; discourse analysis and double expert role in the Hekanaho paper; multi-facet decision making in the Patro et al. paper), *participatory approaches* (Kuure et al.; Patro et al.; and Durall et al.), *education* (multidisciplinary HCI education in the paper by Rajanen and Rajanen; design-driven education in Kuure et al.; STEAM education, arts and design thinking in Durall et al.). *Design* is also seen in many papers as a cornerstone towards achieving the goals in transdisciplinary projects (see Rajanen & Rajanen; Kuure et al.; Durall et al.). In the other two papers, design is part of the development and engineering processes (see Patro et al.; Hekanaho).

## 4.4. TRaD insights on notable results to learn from

All five papers indicate promising results and developments in transdisciplinary research, design and education. The role of the arts; participatory, user-centric and design thinking approaches; reaching out to the general public; aim towards sustainable solutions; critical discourse-oriented lens; understanding and specification of conflicting views; and advancing education are among the observed or predicted results highlighted by the TRaD 2022 papers.

## 4.5. TRaD collaborative reflection

During the conference, the participants engaged in collaborative reflection on transdisciplinarity during the different presentations and particularly in the last session entailing a concluding discussion on core topics. The participants jointly ended up in highlighting the following aspects regarding transdisciplinarity:

- sensitivity towards complexity is essential,
- curiosity on how others think is required,
- a common vocabulary would be valuable,
- awareness raising within different disciplines is needed, and
- questions relating to identity and where one belongs become central.

There are different discourses circulating the use of the term transdisciplinarity, and the participants highlighted how we should critically reflect on what kinds of understandings we are imposing or advancing in our own work. This includes reflecting on the societal and academic circumstances of our work. For example, the relationship to democracy may need closer consideration: does transdisciplinarity aim at more democratic practices and structures? Are transdisciplinary practices inherently promoting more democratic practices? In terms of working in the academia, it was pointed out how it would be important to gain an overall understanding of how academia works: of the diversity of viewpoints, methodologies, epistemologies, statuses in the academic world, of journal policies, writing genres, funding bodies and schemes. This requires one to build a transdisciplinary *professional vision* (see e.g., Goodwin, 1994). For example, for the participants of the conference, digital technology plays an important role as a topic and as a research instrument, and therefore can be seen as part of the professional practice in transdisciplinary projects and education.

One aspect of our work in the academia is the education of future (transdisciplinary) professionals. Participants reflected on what it takes to learn to become transdisciplinary: how to learn to notice what is relevant and to become a professional while at the same time become and be aware of the broader frameworks, and of the work being done across disciplines?

It was also discussed how academics engaging in transdisciplinary research may face struggles in how their work is evaluated, as it is not necessarily easy to publish transdisciplinary research, or to gain funding for it. Therefore, it was concluded that there is a need for structures, people, publication channels, courses and education that offer examples and support for transdisciplinary work. To advance transdisciplinary practices, more information and research is also needed on how to facilitate transdisciplinary research, design, and education, and what the required skills are. Concerted efforts in identifying the strengths, opportunities, weaknesses, and threats in transdisciplinary work was suggested as one way forward.

## 5. Conclusion

This first Mini-Conference on Transdisciplinary Research and Design (TRaD 2022) was organized online to promote and advance the state of the art in transdisciplinary research; to bring together researchers from different academic fields to discuss and explore issues and questions related to experiences and understandings of transdisciplinary work in research, design, and education. We consider TRaD 2022 successful with the five paper presentations supplemented by introductory talks and group online discussions.

The long multidisciplinary research history behind the event provides us better insights into the needs and justifications for transdisciplinary approach as well as to the shared values and interest among the initiators. The connection to increasing and life-changing digitalization of our every-day life is highly emphasized. The multidisciplinary nexus analysis has been successfully used for transdisciplinary research. From a theoretical and methodological perspective, it seems to be a promising strategy for future in the context of exploring complex, transdisciplinary and highly discursive phenomena.

The call for papers for the mini-conference invited authors to share their empirical work and experiences on transdisciplinary research and design. During the actual conference, transdisciplinary education emerged as a focal topic as well. The papers made great efforts towards understanding and defining the concept of transdisciplinarity. All seem to point towards the same direction that issues and topics in relation to transdisciplinarity typically fall between or cross different types of disciplinary as well as professional boundaries. The nature and character of transdisciplinarity was considered as something that evolves as a result of new challenges in society and of the need to address these challenges; builds knowledge beyond, across, and between academic disciplines; and reaches out to non-academic sources and communities while searching for new theoretical and empirical constructs at a higher level of abstraction.

In addition to the conceptual discussion, some practical issues of shared interest were considered in the papers. In the transdisciplinary work reported in the papers and conducted within a variety of different contexts, various approaches have been identified. First, a theoretical, epistemological, and axiomatic perspective of science crossing disciplinary boundaries can be used when observing and

studying the dynamics of different layers of reality within a socio-technical context of interest. Second, in the polymath approach a variety of skills, experiences, and expertise are taken into use when building a holistic understanding of the phenomenon in interest. Third, participatory approaches with several stakeholders and people with diverse backgrounds as well as quantitative evaluation of multi-faced decisions have been used. In the participatory approach, different strategies have been followed like framing, exploration, innovation, and addressing real-world challenges. Finally, the design-driven education approach has been used where the stage-based design process model has been used for a multidisciplinary process of language learning with new technologies.

We wish to thank the authors for their insightful contributions to the discussion on what transdisciplinary research is. The authors and their papers represent a range of different fields, thus promoting discussion between and across disciplines, which was the objective of the mini-conference. The short papers take on different perspectives on the topic of transdisciplinary research, offering various interpretations and shedding light on the complexities involved. We wish to thank all the participants at the mini-conference for joining us in exploring the nature of doing transdisciplinary research and finding new avenues to go further.

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# Transdisciplinarity in HCI

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**Abstract**

Researchers in the Human-Computer Interaction (HCI) field study, design and encapsulate the rich interaction between different kinds of users, information technology systems, and contexts of use in personal and organizational levels with implications to shaping society at large. HCI addresses different levels of analysis in human-technology interaction, utilizes different theoretical perspectives, practices, and paradigms from other disciplines, cooperates with other academic disciplines to study human-technology interaction, crossing boundaries and contributing to other disciplines, and has the design of human-technology interaction in its core. As research and practice field, HCI is very suitable for and oriented towards inter- and multi-disciplinarity, but transdisciplinarity in HCI is not yet fully explored. This paper outlines and reflects upon the concepts of transdisciplinarity, HCI, and transdisciplinarity in HCI.

**Keywords**

Transdisciplinarity, Human-Computer Interaction, Socio-Technical Systems

## 1. Introduction

While some scientific disciplines such as social sciences have been studying technology as part of human life and practices from their own perspectives for a very long time already, other disciplines such as Information and Communication Technology (ICT) have only recently started to address the social science perspectives of technology facing tremendous problems when trying to include them into their own research and practice (Resende et al., 2017). It can be argued that Human-Computer Interaction (HCI), as the most human-oriented discipline within ICT, is responsible for studying and understanding the relationships between individuals, practices, organizations and different contexts in which they use ICT technologies as part of their everyday work and practice to achieve their goals and intentions. As a relatively young discipline, HCI has had freedom in its efforts of developing, expanding and evolving together with technological advances, drawing concepts, theoretical lenses and paradigms conveniently from other disciplines, such as social sciences, cultural anthropology, and engineering, to name a few. HCI is clearly inter- and multidisciplinary by nature, but the role and possibilities of *transdisciplinarity* in HCI have not yet been fully explored. The purpose of this paper is to outline and reflect upon the transdisciplinarity in HCI. We will answer questions such as what are the distinguishing features of the HCI research and practice? what is transdisciplinarity? and what transdisciplinarity in HCI entails.

In the core of HCI research and practice is the interaction between the individual and the computer, technology, software, or hardware through a user interface, which is the only gateway for the user to reach the intended functionalities of the technology. The design of this gateway is at the heart of HCI research and practice (Iivari, 2019). This interaction between humans and technology is encapsulated in the concept of usability.

The international standard ISO 9241-11 (1998) has often been outlined as the classical definition of usability, which consists of the extent to which the users are able to complete their tasks (effectiveness), the time it takes these users to complete their tasks (efficiency) and the subjective experience of the user when completing their tasks (satisfaction). Over time, there have been different variations of the definitions of usability, which act as time capsules, as they outline different approaches, viewpoints and

conceptualizations to usability, thus representing the views and best practices of their time (see e.g., Marghescu, 2009; Rajanen et al., 2017). These usability definitions have been in turn feeding back into their socio-technical environment, thus creating a feedback loop similar to second-order cybernetics (Rajanen & Rajanen, 2020a).

However, it has been argued (see, e.g., Bentley et al., 2016; Rajanen & Rajanen, 2020b) that individual experiences of users of complex socio-technical systems might be strongly determined by subjective reactions to objective aspects and constraints from design and contexts of use. Therefore, it has been argued that due to this subjectivity of individual experiences, the very definition of usability with its subjective satisfaction dimension could be problematic, leading the HCI researchers trying to find objective measures for subjective experiences, to no avail (Rajanen, 2021). To overcome this problem of subjectivity, there have been calls for adopting concepts from other design disciplines, such as architecture, for substituting this subjectivity in the very definition of usability with more universal and objective notions of symmetry and beauty and retaining the individual subjective experiences within the definition of user experience (Rajanen, 2021). These issues highlight the nature of HCI research and practice that learn and adapt from and contribute to other disciplines, especially design-oriented disciplines such as design which is in the very heart of HCI (Iivari, 2019).

Thus, while HCI is clearly inter- and multidisciplinary by nature, the role and possibilities of transdisciplinarity in HCI have not yet been fully explored. The purpose of this paper is to outline and reflect upon transdisciplinarity in HCI. Therefore, in the next section, we outline and reflect upon the different conceptualizations of transdisciplinarity that provide a basis for discussing transdisciplinarity in HCI. In section 3, we discuss the way transdisciplinarity manifests in HCI and provide future research directions.

## 2. Transdisciplinarity

The word *transdisciplinarity* originates from the Latin words *trans-* and *disciplina*, where *disciplina* refers to the existing academic disciplines and the prefix *trans-* adds to it the meaning of "across, on the far side, over, beyond" (Nicolescu, 2000; Cole, 2019). Therefore, transdisciplinarity as a word and as a concept refers to something that is across, between, and beyond the confines of traditional academic disciplines (Nicolescu, 2014; Cole, 2019). Piaget has been credited with the origin of transdisciplinarity, since the academic use of the term can be traced to Piaget's presentations in the 1970s (Nicolescu, 2005; Cole, 2019).

In order to clarify the confusions between the concepts of intra-, cross-, multi-, inter-, and transdisciplinarity, Meeth (1978) outlined a hierarchical classification with increasing levels of complexity, which we expand further with the classifications of Nordahl & Serafin (2008) and Nicolescu (2014):

1. *Intradisciplinarity* focuses on a single discipline, operating within the concepts, methods and paradigms found within one single discipline and never venturing outside its borders (Meeth, 1978; Nordahl & Serafin, 2008).
2. *Crossdisciplinarity* crosses disciplinary boundaries by viewing one discipline from the perspective of another (Meeth, 1978; Nordahl & Serafin, 2008).
3. *Multidisciplinarity* focuses on studying research topics spanning several individual disciplines and while any research topic can benefit by studying it by adding perspectives from multiple disciplines, the goal of the research is limited to the boundaries of the original discipline (Nicolescu, 2014).
4. *Interdisciplinarity* on the other hand transfers methods, processes, practices and paradigms from one discipline to another, but a research goal remains within its discipline (Nicolescu, 2014).
5. *Transdisciplinary* research focuses on research goals that are between, across and beyond individual research disciplines, trying to understand the reality (Nicolescu, 2014).

While this hierarchical classification by Meeth clarifies the individual concepts, it is often unclear what the exact roles and the relationships between inter-, multi-, and transdisciplinarity are. It has been argued that transdisciplinary research is not mutually exclusive to either multidisciplinarity or

interdisciplinarity of research, but rather it should be seen as a concept that complements, expands, and enriches these two other concepts and approaches (Nicolescu, 2000; Max-Neef, 2005; Nicolescu, 2014).

For the purpose of this paper, we can identify two schools of thought or theoretical perspectives into transdisciplinarity: A) Theoretical, epistemological and axiomatic perspective and B) Polymath perspective.

As an example of perspective A, we present three axioms of transdisciplinarity as outlined by Nicolescu (2000; 2014) and Max-Neef (2005):

1. *The ontological axiom*: There are different levels of reality as regards the object and reality of the subject in both nature and society as well as in all knowledge about them. Therefore, the spaces between and beyond individual disciplines are full of information, while an individual discipline focuses on one level of reality or its fragment.

2. *The logical axiom*: The passage from one level of reality to another is ensured by the logic of the included middle, and transdisciplinarity tackles the dynamics of several levels of reality at once, passing through disciplinary knowledge.

3. *The complexity axiom*: The structure of all levels of reality and perception is complex and interdependent; every level is what it is because of the interdependency between all other levels of reality existing at the same time.

While Nicolescu and other researchers of transdisciplinarity such as Max-Neef take this theoretical, epistemological and axiomatic perspective, other researchers take a contrasting view on transdisciplinarity which outlines a more historically-oriented polymath perspective. In this polymath perspective (B), transdisciplinarity is a wide personal set of learning and knowledge, where many scientific disciplines are amalgamated within one individual human called a polymath (see e.g. Terjesen and Politis, 2015; Schikowitz, 2021). This polymath individual has extensive learning from different disciplines, has learned from different research communities, and is capable of utilizing this diverse set of perspectives, theories and methods into a multidisciplinary skillset that can be used to solve complex problems of the world (Terjesen and Polities, 2015). Historical examples of such polymaths include for example Da Vinci, Galilei and Francis Bacon (Terjesen and Politis, 2015). A polymath might not feel committed to any individual discipline, but is rather driven by a need for overarching understanding of the world, and may even consider boundaries set between scientific disciplines as "absurd" (Schikowitz, 2021). However, it can be argued that it is now very difficult for any individual to accumulate the necessary knowledge across many different scientific disciplines due to the scientific disciplines advancing, evolving and expanding. Nevertheless, there are examples of modern polymaths who are capable of crossing disciplinary boundaries, contributing to different disciplines, and even creating new disciplines, such examples of modern polymaths include for example Nobel Laureate Vernon Smith (Terjesen and Politis, 2015).

Next, we take a look at transdisciplinarity in HCI in order to reflect on how these two very different schools of thought or theoretical perspectives into transdisciplinarity can be related to HCI, and what challenges and areas of future research can be found.

## 3. Transdisciplinarity in HCI

From the research areas in HCI, the socio-technical systems approach is perhaps most clearly aligned towards the theoretical, epistemological and axiomatic perspectives of Nicolescu and Max-Neef (for epistemologies for socio-technical HCI perspectives, see e.g., Abdelnour-Nocera & Clemmensen, 2019). The socio-technical systems approach focuses on interactions between technical systems and social systems, aiming to reach a common goal between these two (Bostrom & Heinen, 1977). In order to reach these common goals, it is imperative that the interactions between individuals and technology must be designed well (Mumford, 1983). The socio-technical HCI design focuses on innovative and balanced relations between users, tasks, technology, and organization and has less participatory focus, aiming at designing for organizational capacity, users, and management (Clemmensen, 2021). Some studies have taken the socio-technical HCI further, contrasting the fundamental attributes of usability with classical attributes of architectural design, and arguing that the very concept of usability could act as a mirror of the world (*speculum mundi*) which could be used as a useful lens through which the

impacts of interaction at all levels of socio-technical systems might be observed (Rajanen & Rajanen, 2020b). Therefore, it can be argued that socio-technical HCI as a field can be reflected on the three axioms of transdisciplinarity by Nicolescu (2000), having different layers of reality within the socio-technical context and observing dynamics of these interdependent and complex layers requiring crossing discipline boundaries, and that the relationship between these axioms and socio-technical HCI should be studied further.

Conversely, it can be argued that HCI education is currently leaning towards the polymath approach, aiming at giving the students a wide variety of skills, experiences and expertise to create a holistic understanding which the students can draw from in the future as HCI experts, and drawing from a wide variety of other disciplines, such as psychology, software engineering, information systems, cultural anthropology, game design, data science, business, management, and organization science, to name only a few. Furthermore, it has been argued that the interaction design practices in the HCI field have become more transdisciplinary, requiring a vast variety of skills and expertise, and while this multitude of perspectives to interaction design has potential to support creativity and produce novel design solutions, it can also hinder collaboration between practitioners with different backgrounds in terms of discipline and expertise (Pender & Lamas, 2018). This disconnect between transdisciplinarity theory and practice, where transdisciplinarity on the one hand promises innovative and good design, but on the other hand entails challenges in the very collaboration between different practitioners, poses a challenge for transdisciplinarity in HCI and should be studied further.

## 4. Conclusions

It can be argued that HCI as research and practice is by its history and by its nature very suitable for and oriented towards inter-, multi- and transdisciplinarity, as it 1) has different levels of analysis in human-technology interaction spanning from individuals to organizations and beyond into socio-technical contexts, 2) has a history of freely utilizing different theoretical perspectives, practices, and paradigms from other disciplines, 3) has been used in conjunction with other academic disciplines to study human-technology interaction, 4) has been crossing boundaries and contributing to other disciplines with its research and practice, and 5) has the design of human-technology interaction in its core, and therefore it is closely related to other design-oriented disciplines, learning from them and adapting their core concepts and paradigms.

For future research and challenges in transdisciplinary HCI, special attention should be paid on keeping the design at the very heart of HCI no matter if discipline boundaries are crossed, to use both axiomatic and polymath perspectives on transdisciplinarity in transdisciplinary HCI research and practice, and studying the effects of transdisciplinarity in design from communication and collaboration perspectives.

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# Mapping the divergent perspectives surrounding Finnish hydropower and its removal

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## Abstract

As the values and power relations in the world change, so do the desires regarding water use and recreation. The general appreciation and debate emphasize the importance of rivers and their role in ecosystem functions. Dismantling of dams is seen as one way to restore the diversity of watercourses and, in particular, the natural life cycle of migratory fish. However, in practice, it is evident that other factors besides their ecological benefits influence dam removal decisions. In the past, the large dams suffered from a monodisciplinary view on storing water only for electricity generation. The local population and the environment did not play a major role in the past. Dam removal is inherently transdisciplinary effort, multiple objectives are at stake and have to be addressed concurrently. A transdisciplinary approach is needed to address sustainable water management issues at a local to regional scale, this can be achieved in collaboration with various stakeholders. The main aim of this article is to show how to develop a framework that can support the decision-making process by accommodating the input of different stakeholders while increasing the transparency of the decision analysis process about the future of aging Finnish hydropower dams.

## Keywords
Hydropower; Ageing infrastructures; Stakeholders; Multi-Criteria Decision making; Dam removal; Finland

## 1. Introduction

Current energy and climate policies worldwide induce an increased pressure for a higher share of renewable sources in the global electricity production portfolio. Hydroelectricity has been an attractive energy choice globally as a renewable, flexible, and affordable source (Bonato et al., 2019; Patro et al., 2018; Ranzani et al., 2018). Currently, hydropower is the primary source of electricity in many countries such as Brazil, Canada, Norway, Switzerland, and Austria, while damming the river for power production is still on the rise worldwide (Frey & Linke, 2002; IEA, 2020; Zarfl et al., 2015).

Simultaneously, hydropower development is facing multiple challenges. The massive infrastructures are associated with complex, considerable, intertwined social, economic, and ecological impacts (McNally et al., 2009). The scientific, political, and public concerns about these impacts, which have long been overlooked, are growing (Friedl & Wüest, 2002), leading researchers to investigate the alternative benefits of undammed rivers (Auerbach et al., 2014; Brismar, 2002). Additionally, facilities'

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aging increases operation and maintenance costs to remain secure and efficient (Doyle, Harbor, et al., 2003; Patro et al., 2018). In some drastic instances, these issues have even encouraged the complete dismantlement of hydropower facilities (Gowan et al., 2006; O'Connor et al., 2015; Vahedifard et al., 2020), despite the potential adverse environmental impacts induced by full removals (Pacca, 2007; Stanley & Doyle, 2003).

While hydropower is still the dominant renewable source of energy worldwide, maintenance and operation of aging hydropower infrastructures are becoming increasingly challenging. Reduced reservoir capacity due to sedimentation, increasing security concerns due to the risk of old infrastructure failure, rising maintenance and operation costs, in addition to the realized socio-economic and ecological impacts of reservoirs are among the reasons for questioning the necessity of the continued operation of aged hydropower or complete removal. Transdisciplinary approach is key technique in evaluating multi-faceted decisions regarding the future of hydropower infrastructure as they enable the integration and evaluation of miscellaneous social, economic and ecological aspects (Brennan et al., 2021; Kumar et al., 2022). A common and consensual feature of transdisciplinary assessment approaches is the integration of local specifications and knowledge through local stakeholders' involvement (Lawrence et al., 2022; McGreavy et al., 2021).

The purpose of this work in progress is twofold. First, it attempts to carry out a multi-perspective (social-cultural-ecological-hydrological) analysis to support the decision-makers regarding removal and retrofit. Second, it demonstrates the implications of both the configuration of the process and the consideration of various stakeholders' preferences on hydropower debate and society. Using case studies in Finland, in this article we attempt to understand how the environmental history can support the decision-making process by accommodating the social-cultural-ecological-hydrological-driven multi-criteria perspectives to increase the transparency of the decision analysis process involving multiple criteria and multiple decision-makers.


## 2. Indicators considered for comprehensive evaluation
## 2.1. Changes in hydrology and ecosystem

Damming a river changes the water and sediments, nutrients, and others that move with it through the river system from its smallest headwaters to the mainstream and beyond to a lake or sea. This has several short- and long-term hydrological, physical, and morphological effects. In particular, the natural flow of water, the natural flood cycle, and as sediment drift changes, the structure of the river basin is simplified, and the water temperature can increase or decrease. After the dam, the dammed part of the river is more like a lake, stagnant water ecosystem than the actual river ecosystem. In addition, also inherent strong attachment to the catchment area often weakens. Dam structures smooth out the extreme effects of river flows, reducing their strength and in addition to which the times of flood peaks can be delayed by up to half a year (Ashraf et al., 2016; Graf, 2006; Torabi Haghighi et al., 2014). Dams and reservoirs can modify the chemical composition and temperature of the water, sediment movement, modify the structure of the river basin and floodplains, and generally disturb the continuity of the river ecosystem (Graf, 2006; Santucci et al., 2005). As the climate warms, water bodies are also projected to warm, especially small dams (Firoozi et al., 2020; Sinokrot et al., 1995). Warming contributes to the evaporation of water from the dam basin. Elevated humidity can affect the area's natural rain cycles, intensifying heavy rains (Hossain et al., 2009).

The damming of rivers has a significant impact on the functioning of their ecosystems and the diversity of their species. As a whole, the dam interrupts the river's natural upstream to downstream, interrupting the free movement of organisms in the river network between different parts of the river and in many ways also affects the natural connection with the catchment area. Aquatic species that require their habitat tend to decline or even disappear completely from the dam basin (Hitt et al., 2012; Nieland et al., 2015). Such species that also occur in Finland are, for example, salmon and trout. Dams slow down or prevent the movement of migratory fish between their different habitats (Gido et al., 2015). Large dams often prevent crossing completely, unless fish-bypass structures have been built to assist the

passage (Ashraf et al., 2018), and even then dam basins slow down migration and expose fish to predation and the spread of disease (Huusko et al., 2020).

The dam basin may have accumulated a lot of sediment over the decades. The sudden release of such sediments is the most common concern when planning the removal of dams and cannot be completely certain in advance (Cui et al., 2016; Major et al., 2017). Sediment can easily pass through the river into a larger standing water basin, affecting the water ecosystem only for a very short time, or it may stop in the vicinity of the dam covering and destroying microhabitats (Cannatelli & Curran, 2012). The quality and composition of the sediment accumulated in the dam basin are affected by the climate, upstream geographical and hydrological characteristics, the height and age of the dam, and the characteristics of the snow area (Cui et al., 2016). If a large amount of sediment is released quickly, then in the downstream sediment may accumulate on riverbanks or in estuaries, altering flow conditions, the shape, and water quality of the river (Major et al., 2017). Sediment pulse intensity and the changes it causes in the river are affected by the distance from the dam, the quantity, quality, and periodicity of the discharge, as well as the shape, slope and flow conditions of the river (Doyle et al., 2008; Doyle, Stanley, et al., 2003)

## 2.2. Socio-cultural impacts

The huge postwar reconstruction and modernization project that started in the late 1940's in Northern Finland was a direct consequence of the war years. It changed the physical and cultural environment of the area profoundly. Traditional buildings were replaced by type planned houses, the rivers were dammed to produce hydropower, and new roads were built to serve more efficient forest industry. There is a body of research that has analyzed the social and cultural impacts of damming rivers in Northern Finland (e.g., Autti, 2013; Järvikoski, 1979; Luostarinen, 1982; Rusanen, 1989; Suopajärvi, 2001). The damming of northern rivers focused on engineering and economic growth, while environmental and cultural values at the time were overlooked. The damming of rivers Kemi and Ii was a death blow for rich salmon fishing culture that was centuries old. Damming changed the river landscapes: river areas beneath the dams became dry riverbeds, while elsewhere homes and places for different activities were flooded. The soundscape, scents and the essence of the rivers changed. The new built environment included power plants, dams, and electricity distribution constructions. These rapid changes caused a disconnection between local people and their environment: the active role of people living along the rivers turned to passive observing, and many lost their sense of belonging. The change in the environment shook the bases of human-environment relationship of many in the area, and the impacts easily spread to all walks of life: on well-being, economy, social life, and local culture.

Environmental and cultural changes speeded up the structural and economic change in local communities. Significant salmon fishing cultures vanished quickly, and the importance of other livelihoods such as crofting, logging and log floating also declined. Unemployment caused migration to Sweden and cities in Southern Finland. The change in the traditional livelihoods broke the shared reality of older and younger generations and created a social gap between them. Older generation felt useless in the new situation. Their work was no longer appreciated, and younger generation left the area to study and work elsewhere. This had a negative impact on the sense of belonging, place attachment and participation in local communities, moreover the unwanted change weakened the residents' experienced health and wellbeing. Environmental change and its further consequences resulted as experiences of collective and personal environment related traumas (Autti, 2022).

Over the last two decades, the attitudes towards dammed rivers in Northern Finland have started to change course. Social acceptance of hydropower has weakened, and alternative ways of river use have become subject of public debate. For example, many projects that aim to reintroduce salmon have tried to find ways to combine different water use interests and hydropower and migratory fish to coexist. Dam removals elsewhere or in smaller rivers have opened new sights for river restoration also in the northern context. However, from the cultural transformation point of view, dam removal process is yet again alteration of the existing situation and existing landscape. Damming has shaped the history of Northern Finland as it has brought about new activities and new people in the area, as well as new

connections, new experiences, and memories. Dam demolition will not take us to the situation before them, but rather leads to a new situation.

Hydropower related architecture and built environment are also part of the environmental history in the area. Many power plant entities have been classified as a nationally significant built cultural environment (RKY). Power plants and related residential areas were one of Finland's most important construction projects during the reconstruction period, and they are of tangible and intangible significance (Kinnunen, 2018). Many of the power plants were designed by Finland's leading architects. The planning provided an opportunity to test and apply architectural ideas at all levels, from spatial planning to the smallest building details. The structure of the power plant communities follows the open ideology of urban planning that blends in with nature and the landscape, but also the hierarchical, early industrial community structure.

Issues related to cultural heritage can be fundamentally contradictory (Soikkeli, 2005). The cultural heritage of hydropower can be a source of shared memories, understanding, identity, community, and creativity, in much the same way as the pre-dam cultural environment. The question of social justice and the traumatic histories of environmental change call for a methodological principle and aim to better involve local communities in planning processes. New ways of participation should be developed in which various interpretations of the past, as well as various views concerning the use of the rivers and river landscapes, are acknowledged. River restoration needs to be studied and discussed more widely than just through water management or ecological factors: we need research on social and cultural connections and impacts, we need to include the aspects of social justice and cultural heritage, and most importantly, involve stakeholders to participate and share their experiences and interests.

## 3. The way forward

The comprehensive evaluation of hydropower rehabilitation and removal is a complex and uncertain process that includes physical, hydrological, ecological, and social aspects. A quantitative and qualitative analysis method that can deal with multiple indicators and fuzziness is required. We also lack information about the effects of dam removal on the environment. Restoring or removal of hydropower projects will require careful planning, close monitoring of the state of the river, ecosystem, and local population. The work is in progress to understand the Finnish dam rehabilitation and removal issues from a transdisciplinary approach to address socio-economic, technological, and regulatory barriers. Such a transdisciplinary approach to hydropower rehabilitation is lacking. Such an evaluation approach considering local circumstances, will present more feasible guidance for local river eco-environmental and hydropower management. The main finding so far is a transdisciplinary approach is one way of better understanding some of the conflicting viewpoints evident in discipline-based approaches of narratives over the implications of the hydropower dams.

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# Transdisciplinary education and innovation through STEAM

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## Abstract

While the concept of transdisciplinarity has been widely discussed in research, there are still challenges for its translation into practice. In this paper we elaborate on the concept of STEAM (Science, Technology, Engineering, Arts and Mathematics) as a nexus for transdisciplinary practices in research, teaching and project design. We introduce the STEAM Innovation and Curriculum project and analyse a set of cases identifying different approaches to transdisciplinary practice in higher education (HE) which include framing, inspiring, exploring, challenge addressing and innovating. Each of the approaches is connected to a set of strategies together with some examples. We reflect on the commonalities between the different STEAM approaches since they can offer opportunities for facilitating effective transdisciplinary practices in research and HE leading to innovation.

## 1. Introduction

Attention to transdisciplinarity is not new with several international conferences and key work produced in the past five decades. It is, however, a concept that has caused confusion about what it actually means - including, how it differs from interdisciplinarity and multidisciplinarity - and has posed challenges in its translation into practice. We align our definition of transdisciplinarity to that proposed by Erich Jantsch (1972; Augsburg, 2014) and applied in published work since (e.g. Tress et al., 2005; Nicolescu, 2004). Therefore, for us transdisciplinarity includes a realistic setting, acknowledgement of complexity and working across, between and beyond disciplinary boundaries.

It differs from interdisciplinarity, which integrates different disciplinary knowledge systems to create new methodological approaches, by going beyond breaking down disciplinary barriers through reaching out to external knowledge (such as policy-making and practice knowledge, or local and indigenous knowledge). As Darbellay (2015: 165) observes, "undisciplined knowledge" involves rethinking disciplinary identities and presents a different thought style. Figure 1 illustrates the differences and characterises the inherent principles for transdisciplinarity drawing on insights gained from across the literature and own research experience.
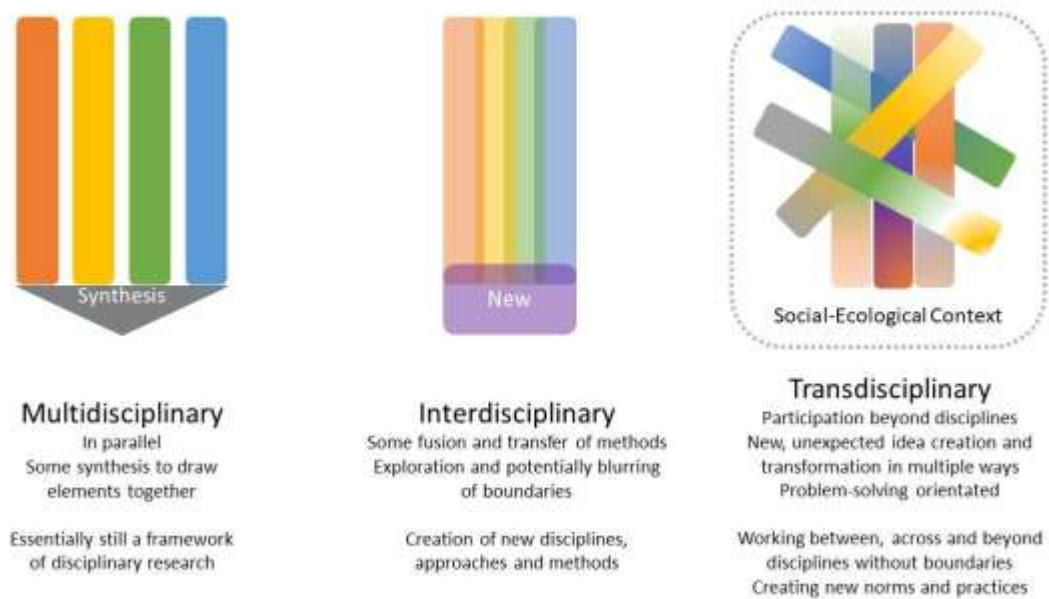
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**Figure 1**: Explaining the differences between Multi-, Inter- and Transdisciplinarity

Looking at the context and characteristics of transdisciplinarity, similarities become obvious with 'STEAM', an agenda that arose from attempts to inject 'Arts' (A) into Science, Technology, Engineering and Maths (STEM); or more broadly to adopt creative Arts and/or Design based approaches to other academic fields. STEAM approaches allow the framing and analysing complex current challenges in critical and cross-cutting, holistic ways, stimulating innovative thinking and solutions through co-production and reflection (Catterall, 2017; Colucci-Gray et al., 2019). Further, methods have found traction in primary and secondary education, but are relatively new to tertiary (or higher) education. However, they have been gathering momentum for opening up research and (extra-) curricular pedagogy, stimulating social learning and innovation through collaboration with industry, practitioners and/or community involvement (Carter et al., 2021).

Recent work, conducted as part of the STEAM Innovation and Curriculum (STEAM INC) project to help clarify and develop guidance for STEAM approaches and methods in higher education (HE), suggests that STEAM is an opportune setting to facilitate transdisciplinarity. The sharing of common principles, as for example captured in the Charter for Transdisciplinarity (de Freitas et al., 1994) or Nicolescu's (2014) Methodology of Transdisciplinarity is evident. Key themes for STEAM and transdisciplinarity are further unpacked and discussed in the following sections, following an overview of the STEAM Innovation and Curriculum project and its key outputs.

## 2. STEAM innovation and curriculum

## 2.1. Project overview and outputs

STEAM Innovation and Curriculum (STEAM INC) is an Erasmus+ funded collaboration between seven European partner organisations who have a common interest in STEAM approaches and methods (Table 1).

**Table 1**
The STEAM INC project partners

| Institution | Country | Specific role |
|---|---|---|
| Birmingham City University | England, U.K. | Project lead; Objective 1 lead |
| Central Saint Martins College, University of the Arts London | England, U.K. | Objective 2 lead |
| Science Gallery Dublin, Trinity College Dublin | Ireland | Objective 3 lead |
| Aalto University | Finland | |
| Amsterdam University | The Netherlands | |
| Dresden Technical University | Germany | |
| Ars Electronica | Austria | |

STEAM INC started in October 2019 and finishes in January 2023. It has three major objectives:

1. Identify points of intersection across current European HE STEAM approaches and develop a collaborative definition of HE STEAM.
2. Produce methodologies for the implementation of STEAM thinking in HE education, policy and engagement.
3. Create an evaluation framework for measuring the effectiveness of STEAM processes in HE institutions and HE partner organisations.

To realise its objectives, STEAM INC has held partner meetings, workshops, training events and conferences. Apart from the very first partner meeting in December 2019 in Amsterdam, all activities have been held online due to the COVID19 pandemic, often using collaborative software such as Miro. Techniques employed in sessions include templates, peer review, reflection and 'hacking' (deconstructing something and then taking elements/inspiration from across other sources to reconstruct it in a different way).

Selected activities, key to the deliberations presented in this paper, are described in the following. Where the activity is complete, a link to the relevant output is indicated, if applicable. The work is also described in greater detail by Carter et al. (2021).

To achieve the project objectives, it was vital that there was a mutually agreed understanding of what STEAM means in the partnership. This was the focus of a workshop held during the first partner meeting in Amsterdam in 2019 and has since been revisited and further reflected upon.

Each partner presented a definition of STEAM that reflected their understanding and experience. This was followed by group work that assembled key and recurring words that were then evaluated and prioritised. Finally, an agreed definition emerged that encapsulated the collective understanding of what is contained in a STEAM approach. This comprised a set of baseline attributes for a STEAM practitioner or process (expressed for the HE context but more widely applicable) which was embedded into STEAM INC's working definition:

- a culture (or cultures) that puts the Arts and Sciences on an equal footing;
- operating within a paradigm that is process-driven, student-centred, holistic and provides permission to fail alongside being comfortable with uncertain end-results;
- being collaborative, diverse and delivered through safe spaces;
- establishing a mindset of radical openness, flexibility, reflection, experimentation and curiosity;
- generating qualities that promote learning, cooperation and multi-modality;
- developing competencies of critical thinking, creativity and communication whilst investigating how these can be applied to generate solutions".
- developing competencies of critical thinking, creativity and communication whilst investigating how these can be applied to generate solutions.

Work on the handbook began in March 2020, when each partner presented two STEAM approaches at an online training event. While limited by being set in a Higher Education context,

choices were flexible to represent examples from curriculum development, external engagement and policy (internal or external).

The event included a period of reflection where attendees considered the commonalities and differences of the approaches as well as key features. The resulting themes were then further refined by the lead partner. This work was complemented by the development of the handbook (Burns et al., 2021), which includes brief descriptions of the approaches[2], detailed advice for implementing STEAM approaches in Higher Education and reflection regarding the tensions and ambiguities arising through the project and STEAM approaches as a whole. It is this work that has primarily informed the findings of this paper.

To fulfil the second project objective the partnership has developed new STEAM methods. This has entailed presentations of existing methods, that were then critiqued and dismantled. The new methods are either an improved version of an existing method, a hybrid of several methods, or something completely new, inspired by working through the hacking process. This is nearing completion with the methods available on the project website at https://www.steaminnovation.org/resources.

Finally, to realise the third objective, the partnership is developing a new toolkit to evaluate the effectiveness of transdisciplinary cooperation across STEAM disciplines. This aims to measure the value of unconventional methods arising from STEAM activities as well as assessing their significance in the development of curriculum, engagement, and policy.

All together, the project outputs provide a picture of current STEAM practice in HE as well as providing a practical toolkit which will enable and engender expansion of the field.

## 2.2.   Selection of cases

The cases included in the STEAM INC project consist of initiatives developed by the project partners focused on supporting and promoting inter-/transdisciplinary research and/or learning in HE. While some of the initiatives might be considered as public engagement, so addressing a public beyond academia, they maintain strong links with universities. In this section, we introduce the cases and provide a brief outline of each.

- **Aalto Biofilia** is a biology lab in an arts school. This learning environment supports exploring life sciences in arts contexts as well as providing a research space for artists, researchers and students in the Aalto School of Arts, Design and Architecture.
- **Aalto University Wide Arts** Studies is an elective courses programme on art and design-based practices and processes targeting students from all faculties.
- **Birmingham City University's STEAMhouse** provides an innovation and business development centre fostering collaborations around STEAM. The centre brings together artists, engineers, entrepreneurs, companies, and public sector organisations in events and training oriented at idea generation, as well as product and service development.
- **Birmingham City University** - Jo Berry's research involved explorations between art and science and employed 'play' to generate new methods and insights in scientific data applications.
- **Central Saint Martins MA Art and Science** is a Master's Degree programme exploring contemporary and historical relations between art and science, working in non-hierarchical transdisciplinary and collaborative ways. As part of the Masters programme relations with external actors and institutions from different fields have been forged and resulted in a range of public-facing events and off-campus activities.
- **Science Gallery Dublin (SGD)[3] at Trinity College Dublin** was a cultural and educational space and part of the Science Gallery Network. SGD was focused on triggering conversations about science and art, targeting young adults.

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[2] The STEAM approaches are also explained in greater detail on the project website: https://www.steaminnovation.org/resources.
[3] Sadly, funding for the Science Gallery Dublin stopped in 2022.

- **Science Gallery Dublin - "Idea Translation Lab"** was an elective module for undergraduate students from diverse faculties. In the course, students engaged in collaborative projects focused on societal challenges.
- **Dresden University of Technology - "Interdisciplinary summer project"** is an Industrial Design Engineering course. Participants are students from design, engineering and technology studies. During the project, they work together on challenges provided by companies, as well as research and cultural institutions.
- **Dresden University of Technology - Module on Bionics** is a cross-disciplinary course introducing Bachelor students to core aspects of Bionics from the perspective of Biology, Mathematics and Engineering.
- **University of Amsterdam - Bachelor and a Master programmes on Information Studies** combines STEM fields with Arts to broaden students' perspectives around information systems, encouraging them to consider the human and social needs before developing any technological solution.
- **University of Amsterdam - Humans, Science and Technology** is an academic programme preparing students to address societal complex challenges. The programme is a joint endeavour of the faculties of social sciences, humanities, and science.
- **Ars Electronica - STARTS programme** supports innovative projects at the nexus of science, technology, and the arts by creating a platform for collaboration between artists and industry.

## 3. Results and discussion

A thematic analysis of the cases selected by the STEAM INC partners has been performed to identify different approaches to transdisciplinary design and research in policy, engagement, and education in higher education. Five themes emerged as central to all approaches: framing, inspiring, exploring, challenge-addressing (or a social-ecological or social-technical context), and innovating. While all the themes have been found present in all the cases, we consider the differentiation between themes a valuable contribution since it helps to understand where the emphasis is placed. Next, we elaborate on each of the themes, presenting the key strategies that characterise the approach, together with some examples from the cases.

**Framing** refers to STEAM approaches aiming to create and foster a transdisciplinary thinking mindset. The focus is on opening up perspectives and embracing new ways of looking at things so that current social-ecological challenges can be better understood and explored. This then helps create greater awareness of the opportunities and limitations of different methods and ways of thinking. In STEAM INC, the cases that were linked to framing included programmes, such as the University of Amsterdam's new Master's in Humans, Science and Technology. Some of the strategies used to support transdisciplinary thinking focused on using different modes of analysis pertaining to different disciplines/perspectives and triggering out-of-the-box thinking to explore divergent views. From an institutional perspective, enabling and fostering close collaboration with different departments and faculties, as well as including various stakeholders, who might be external to the institution (such as alumni) was key for broadening understanding and ensuring the programme was rooted in transdisciplinary practice.

While all the cases used inter-/transdisciplinarity to spark new ways of thinking and tackling current societal needs and challenges, in some of the cases a clear endeavour for inspiring was evident. For instance, in the module on bionics offered at Technical University Dresden, the effort focused on inspiring the next generation of professionals to use creative approaches for bridging different areas of knowledge. Demonstration and modelling were an important component of this module, in which students were introduced to fundamental aspects of Biology, Mathematics and Engineering and encouraged to connect these different areas of knowledge through projects with external partners and design solutions. In other cases, such as the Science Gallery Dublin - Trinity College Dublin, the mission was to inspire the general public. The Science Gallery Dublin's motto "connect, participate, surprise" captured the main strategies used to inspire their audiences, through

offering a social space to spark conversations and trigger curiosity about current issues, from a transdisciplinary point of view.

The creation of knowledge-sharing opportunities between experts from different fields was another strategy to inspire and foster transdisciplinary collaborations. For instance, at Birmingham City University, Jo Berry's artistic work using advanced imaging and microscopy to create links between arts and sciences exemplified how artists' residencies, in which artists collaborate with scientists, can lead to novel ideas and open up transdisciplinary perspectives and ways of researching/working. This work also found that it takes time to create a 'common' language and shared/better understanding of concepts and meanings amongst the collaborators.

Transdisciplinary work can be regarded as an **exploratory** quest for producing new concepts, tools and ways of doing to help formulate or develop solutions towards social-ecological challenges. Thus, cultivating ways to conduct explorations in a transdisciplinary way is considered critical. In our analysis, some of the strategies commonly used to support transdisciplinary explorations consisted of introducing methods from one field into another, but also through embracing creative methodologies to make links between the arts and sciences. Aalto University's initiatives such as 'Biofilia' and the university-wide 'Arts Studies' are examples of the various ways in which transdisciplinary explorations can be embedded in HE.

In BCU's STEAMhouse and TU Dresden's 'Interdisciplinary Summer Project' a link with industry and/or other external stakeholders created the opportunity to **address** real-world **challenges** through fast-paced exploration and creative processes drawing on transdisciplinary knowledge and team-working. Such collaborative approaches, in which participants are encouraged to work on projects with societal actors or industry, was another strategy to support transdisciplinary explorations and addressing complex social-ecological challenges. Similarly, Central Saint Martins's MA Art and Science programme puts a strong emphasis on relation-building (within, between and beyond). This is an integral part of the programme's transdisciplinary approach to STEAM, maintaining a strong link between academia and practice, with a focus on current day challenges or emerging issues.

A common reasoning regarding the value of transdisciplinarity relates to being better equipped for addressing and **innovating** solutions for current challenges. The STEAM INC project showcased many project-based approaches to nurture collaborations between academics, students, and external actors to academia. These collaborations were perceived as key for addressing problems in a transdisciplinary fashion. In innovation-oriented initiatives such as Birmingham City University STEAMHouse, design thinking strategies have been introduced to the academic and professional community to spark innovations. In other cases, such as in the Arts Electronica STARTS programme, the creation of a platform for collaboration between art and industry was a key instrument for sustaining transdisciplinary innovations.

While the emphasis among the approaches outlined in this section might vary, many of them build on strategies focused on supporting collaborations with diverse knowledge holders, actors and communities, as well as expanding the methods repertoire borrowing from other fields of knowledge and creating fused or novel approaches and methods. Another important aspect is the role of design. In the cases analysed in the STEAM INC project, design (or a design thinking approach) has frequently been used as a glue to link different fields of knowledge, ideating, and developing solutions to address a current challenge. We consider it important to highlight these commonalities since it can offer avenues to implement transdisciplinarity in research and create innovation projects using STEAM approaches and methods.

## 4. Conclusions

The current drive to develop and apply STEAM approaches in education and analysing specific approaches and learning in the STEAM INC project, showcased a range of insights about how STEAM approaches can effectively facilitate transdisciplinary working. STEAM and transdisciplinarity share many principles and highlight how STEAM has inter-/transdisciplinarity at its core. The five themes identified in our analysis - framing, inspiring, exploring, addressing challenges, and innovating - help characterise vital ingredients for successful transdisciplinary projects and teams. Importantly, the role of the Arts and the influence of design thinking (and

adopting a user-centric lens) can help overcome disciplinary barriers and narrow mindsets. They have emerged as catalysts for wider/novel framing of issues, inspiration, exploration, and innovation and as a 'glue' in transdisciplinary projects and teams for developing 'solutions' to help address complex challenges. Furthermore, the Arts, and artistic approaches, are a critical component in their own right alongside other disciplines (Carter et al., 2021) and deserve due attention as part of transdisciplinary working/projects.

STEAM approaches (as outlined in section 2.2 and Carter et al., 2021; and the STEAM INC Handbook / Burns et al., 2021) and methods belonging to different disciplines (e.g. hacking from IT/computing) can be applied or reconfigured in new ways to help innovate and meld ways of conceiving, analysing issues and/or designing and creating solutions. STEAM approaches can be challenging by placing participants out of their comfort zone and approaching an issue from diverse perspectives and in novel ways. In the education sector the link with practice and policy (beyond academic) and moving from inter- to transdisciplinary working seems an important step for empowering students and staff to help tackle social-ecological challenges and become more grounded, multi-skilled and creative in their inquiry and production of outputs.

We concur with Hans Dieleman (2015) who links "reflective action and artful doing" and emphasises "spaces of experimentation and imagination" (p.68) to characterise transdisciplinarity which "should be considered as both a transformative process as well as an epistemological, ontological and methodological endeavor" (p.69).


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# Design-driven language teacher education as a transdisciplinary field

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## Abstract

Today's learning spaces and practices are characterized by hybridity. Design-driven approaches and transdisciplinary collaboration have been suggested to contribute to the renewal of language pedagogy, where the change has been slow. However, the concepts of design and transdisciplinarity can be used in various ways. This study introduces a synthesis of the authors' design-driven view on language teacher education, which draws on sociocultural-ecological learning theory and relies on nexus analysis as a research strategy and tool for transformation. A design-driven course model is used to illustrate the complexity of change and opportunities for transdisciplinary collaboration. The findings have relevance for appropriating design-driven approaches in language teacher education and in creating a basis for transdisciplinary collaboration.

## Keywords
Design-driven learning, language teacher education, nexus analysis, transdisciplinarity

## 1. Introduction

In terms of digital competence, teacher education is in the key role in preparing future language teachers for a professional life that includes constant technological change (Hubbard, 2019). To be able to utilize both familiar and new technologies in language learning and teaching, and to act as a modern language teacher in general, a range of different kinds of competences is required (Kessler & Hubbard, 2017). Digitalization and ubiquitous technologies have transformed interaction in our everyday environments that have become hybrid spaces merging the material and the digital (Ryberg et al., 2018). In hybrid spaces, which Pischetola (2022) characterizes as sociomaterial assemblages, the boundaries between the private and the professional are blurring, challenging the practices of language education as well. These perspectives raise the demand for multidisciplinary research collaboration that would capture the complexity of social action in hybrid environments and advance change.

The transformation of our communicative environment and the broadening range of resources creates a natural context for advancing language learning as multimodal, meaningful interaction (see van Lier, 2007). However, based on a review of recent research done on computer-assisted language learning during a ten-year period, studies on the 'four skills' (reading, writing, speaking and listening) have dominated the field, while studies on modern learning environments and different technology-enhanced learning designs (e.g., games and virtual reality) have received much less attention (Gillespie, 2020). There is thus a need for research that would support the development of new kinds of holistic learning designs that incorporate not only digital competence but at the same time embrace other current issues in language education such as language awareness, multiculturalism or multidisciplinarity (Finkbeiner & White, 2017; Finnish National Board of Education, 2016; see also Kuure et al., 2020).

The changes described above have foregrounded several issues and questions related to the pedagogical approaches applied in textbook-driven language education and classroom-focused

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language teacher education. A conceptual change of seeing teaching as designing for learning has been suggested as an answer to meet the changing demands and to transform practices of teaching (see, e.g., Laurillard, 2012; Ryberg et al., 2015; Schön, 1987). At the same time, transdisciplinarity has been considered natural and necessary in designing for language learning (Colpaert, 2018; Hubbard & Colpaert, 2019). Still, both design and transdisciplinarity are complex perspectives to integrate into education.

This paper discusses design-driven language teacher education as a transdisciplinary field through an example of a course model developed at our university to trigger change in the practices of language teaching. Design is understood here broadly as a collaborative, problem-based working process that advances from problem-formulation, background research, ideation, concept generation and prototype preparation to experimentation with schools or other contexts for language learning. The course aims to offer pre-service teachers a new perspective to language teaching as designing for language learning and places pedagogical action as the object of design. On this course, pre-service teachers have designed and put into practice language projects for schoolchildren and learners of different kinds. We have tackled change and the complex entanglements of aspects hindering it using nexus analysis as a research strategy and tool for transformation (Scollon & Scollon, 2004).

## 2. Nexus analysis, design and transdisciplinarity

The concepts of design and transdisciplinarity need to be discussed next in more detail as they both have been perceived in different ways and applied variably in education. In addition, our theoretical and methodological perspective to social action, nexus analysis (Scollon & Scollon, 2004), is described below as it has provided us with an important tool to examine the complex entanglements of actions and practices, interactions, and discourses – both situated and wider-scale – in the field of language pedagogy in our case example, the design-driven course.

Nexus analysis provides us with a theoretical lens to social action, seen as an intersection of discourse cycles of interaction orders, historical bodies and discourses in place (Scollon & Scollon, 2004). It also involves a research strategy with a participatory, ethnographic stance, proceeding from engaging, through navigating to changing the nexus of practice (Scollon & Scollon, 2004). From a nexus-analytical perspective, interdisciplinary collaboration emerges as a semiotic ecosystem of a range of actors, contextual circumstances and discourses across diverse timescales and places where the researchers need to make sense of their position (Kuure et al., 2020).

Design-driven approaches to technology-mediated language education have gained popularity in recent years (Reeves & McKenney, 2013; Özvenir et al., 2021). It facilitates an iterative, cyclical process promoting an effective dialogue between theory and practice in teaching as the pedagogical action is design building on earlier research and experiments (Laurillard, 2012, p. 211-212). Accordingly, a design-driven approach provides a good framework for research aiming to improve educational practices and viewing teacher education as situated and reflective practice (Özvenir et al., 2021, p. 346; Schön, 1987). Design-driven projects have been highlighted as bringing along future orientation and facilitating change in the pedagogical tradition (Blin & Jalkanen, 2014).

Design principles often show in the iterative organisation of the research that builds on experiments in real-world-settings through careful evaluation and reflection (Özvenir et al., 2021, p.325). The process allows for a dialogue between theory and practice which provides affordances for the professional development of the participating practitioners (Reeves & McKenney, 2013, p.13). Design-driven approaches also entail teamwork promoting transdisciplinary collaboration between different stakeholders in the project (Kuure et al., 2020; see also Ryberg et al., 2015).

A well-known definition of transdisciplinarity comes from Choi and Pak (2006, p. 351) who see it as transcending traditional disciplinary boundaries. The notion of transdisciplinarity in the field of language education is characterized with different emphases in academia. Byrd Clark (2016) summarizes transdisciplinary approaches broadly as envisioning alternative ways of thinking and doing language learning and teaching (p. 5). Colpaert (2018) defines it as "the ontological specification of knowledge constructs on a higher, boundary-transcending, level of abstraction" (p. 485). What these disciplinary boundaries are and what transcending entails vary in researchers' accounts of the concepts.

The Douglas Fir Group (2016) with a focus on second language acquisition direct their transdisciplinary call to researchers "to expand their analytic gaze to different dimensions of social activity and—without necessarily giving up or even expanding their particular approach—to think integratively" (p. 38). They consider transdisciplinarity to arise by participants detaching themselves from their disciplines and strands within them through a problem-oriented stance in addressing real-world issues (p. 20). The disciplines they mention fall within human sciences (e.g., linguistics, sociolinguistics, neuropsychology, psychology, educational science and sociology).

In schools, STEAM education integrates subjects drawing on science, technology, engineering, arts and mathematics through project-driven approaches which are often situated in the teaching of transversal competences, e.g., through making projects and digital fabrication (Finnish National Board of Education, 2016; Iivari et al., 2017). In the case of language teacher education, collaboration beyond the humanities has been scarce. This study, however, presents a case that has been drawing on a design-driven pedagogical approach with pre-service teachers, sometimes in collaboration with participants from the fields of engineering, human-computer interaction, and participatory design (see, e.g., Kuure, et al., 2016; Tumelius & Kuure, 2021).

## 3. Design-driven course for pre-service teachers

The design-driven course for pre-service teachers discussed here has been included in the curriculum of English studies since the beginning of 2000s as an elective, master's-level unit directed to future language teachers or language professionals in other fields of education. What is now called design-driven was originally a loosely project- or problem-based approach. The emphasis on the design process has arisen due to collaboration with different participants from information technology and language technology companies, as well as university units in engineering, human-computer interaction and participatory design. As mentioned above, the course work has advanced from problem-formulation, background research, ideation, concept generation and prototype preparation to experimentation with schools or other contexts for language learning. The work involves collaboration and teamwork as well as continuous reflection and sense making throughout the process.

The research conducted on the different course iterations over the years has shown how changing the traditional teacher-led interaction order, providing room for exploring one's understandings relating to language teaching and learning (historical bodies), and breaking out of the classroom-based space to the hybrid spaces (discourses in place), have provided concrete means for contributing to change in the prevalent discourses on language teacher education and the teacher's role. For example, the learning activities have been organized in a manner which have allowed the pre-service teachers to take an active role, and as Tumelius and Kuure (2021) and Tumelius and Kuure (2022) show in their analyses of one course iteration, the confined office space where the course teacher and the pre-service teachers worked then in collaboration, orchestrating the online course activities from there, functioned as a central hub that allowed for joint negotiation of meanings and supported the pre-service teachers' positioning themselves as active agents. Koivistoinen et al. (2016) discuss how wrap-up discussions during the course allowed for the creation of shared narratives of what the design-driven course process has been like, and thereby for taking ownership in the course activities and the learning outcomes. Other observations on how the pedagogic design of the course has supported pre-services teachers are discussed in Kuure et al. (2013). They observe, for example, how the choices the teacher had made in designing the virtual learning environment, allowing extensive access rights and tools for participant-driven collaboration for the pre-service teachers, had been done with the aim of supporting more varied interaction between the course participants.

In terms of transdisciplinarity, many of the course iterations have involved the participation of technology developers in the concept design phase. In some cases, the collaboration has remained minimal, and even a disappointment when pre-service teachers have been positioned in a tester role as users despite our expectations of true dialogue for a shared goal. However, there are also examples of fruitful collaboration as Riekki (2016) shows in her study dealing with the interaction and sense making between pre-service teachers on two of the courses and technology developers. Thus, the course iterations have also involved transdisciplinary collaboration as regards the partners' dialogue creating something new and even unexpected. In the first case, the technology developers introduced two

applications to be used for language learning and teaching, one for the pupils for adventure gaming through NFC technology (Near-Field Communication) and one for the teacher to create those learning games for the pupils. The technology developers were actively asking the pre-service teachers questions concerning the daily life and the nature of learning and teaching at school to understand the viability of their application. The pre-service teachers' questions and ponderings were related to how their ideas could be considered in programming the game and editor. The discussions around the reality of school life as regards the attempts to move from primarily teacher-guided activities to support pupils' agency led to the technology developers rejecting the idea of two applications and continue with one, suitable for any user at school. In the case of another course iteration, the same group of technology developers was working with pre-service teachers creating a game scenario for a school theme week. Here, the use situation advanced from pupils playing ready-made NFC games to creating games themselves by pencil and paper. This changed the setting for pedagogical design but also the approach to technology testing (Riekki, 2016, see also Kuure et al., 2016). In the following, these two perspectives of design and transdisciplinarity are elaborated further.

## 4.  Discussion and conclusion

The examples as well as our experiences from the course iterations discussed above suggest that the design approach has been fruitful in exploring change from traditional practices of language education towards new practices building on technology-rich, hybrid environments as sites for language learning and teaching. The solution related to the project-based working model in our case course was to place the teacher as one of the co-participants among the pre-service teachers. Thus, the designs in progress were equally new and hazy for her as they were for the pre-service teachers. Such a situation provided affordances for the emergence of a balanced interaction order, which again gave space for new discourses and practices, and opportunities for the pre-service teachers to assume agency over the project (see Tumelius & Kuure, in review).

The studies highlight the complexity of aspects entangled to the nexus of practice of language teaching in hybrid spaces, and language teacher education through design-driven projects. The design projects have involved a wide range of participants from schools, different disciplinary fields, students and pre-service teachers with their personal interests and career plans. The infrastructure in schools and at the university has also played an important role in how the pre-service teachers' designs have proceeded based on how the pedagogical plans can be fitted into the available technological tools and facilities, timetables, and support among others. In this way, the design projects, even if challenging at times, have functioned as real-life environments for the pre-service teachers to become familiar with managing chaos and complexity and assume agency in creating new approaches rather than rely on traditional practices of language teaching.

The design-driven course advances transdisciplinarity in various ways. On the one hand, it encourages the participants to become acquainted with alternative ways of thinking and doing language learning, as the pre-service teachers need to renew their vision and approach of language education towards hybrid environments rather than familiar settings (Byrd Clark, 2016). This requires sense making and integrative thinking on a higher level of abstraction transcending accustomed boundaries (Colpaert, 2018; The Douglas Fir Group, 2016). On the other hand, the design approach as applied on the course involves collaboration with professionals in engineering, human computer interaction and participatory design allowing the pre-service teachers to explore practices and perspectives in disciplines beyond their own (Choi & Pak, 2006; Ryberg et al. 2015). Design-driven language teacher education focusing on transdisciplinary practice has the potential of renewing the pre-service teachers' professional profile and strengthening their agency in becoming change agents after graduation.

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# Diversity in product teams – A discourses survey

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**Abstract**
This paper introduces the results of a discourses survey on a sample of online content on the topic of demographic diversity in product development teams. Three main discourses were identified where the first two work to justify or explain the need for demographic diversity, and the third one to create boundaries for acceptable diversity and its expression in the workplace. Each discourse is geared to its specific audience and when looked at together, shows discrepancies between accepted narratives. This is perceived as evidence of the complexity of the topic and the maturity of the current conversation.

**Keywords**
Discourse, diversity, product development, discourses survey

## 1. Introduction

With the rise of more agile and iterative product development processes, the role of experts has become more important. Successful companies such as Netflix, believe that problems are best solved by the people closest to them, which results in more decision-making happening on the team level (e.g., Hastings & Meyer, 2020). This again results in more attention being paid to what kinds of team compositions and processes make teams the most effective. One example of such attention is Google's (2015) study on effective teams which is often referred to in product development process conversations.

One popular unit structure in product development is a 'cross-functional team' consisting of representatives of different disciplines, such as business, design, and engineering. The assumption is that varied educational backgrounds result in a wider perspective and therefore more innovative products, better product quality, faster execution, and ultimately a more successful business. In more recent years, the diversity considered has evolved from age, tenure, and discipline to include an array of demographic markers such as class, gender, race, religion, sexuality, and ability. (Gladstein Ancona & Caldwell, 1992; Sethi, 2002; Gebert, Boerner & Kearney, 2006; Dayan, Ozer & Almazrouei, 2017).

This paper applies the method of discourses survey to look at media content on the topic of product team diversity. I will look at discourses justifying diversity in product teams, and others discussing the kind of diversity encouraged. My hypothesis is that when companies talk about diversity, they mean only a certain, preapproved type of diversity, and the expression of diversity is regulated. My twenty years of experience practicing product design in cross-functional product teams provides a backdrop that I use to situate the texts in the business and technology content landscape. This combination grounds this paper in transdisciplinary research: I examine a multidisciplinary environment combining the lenses of a researcher of one discipline and the practitioner of another in the hopes of uncovering new knowledge between the disciplines.

## 2. Research process

Discourses survey, a method within nexus analysis, can be used to look for interesting issues to examine more closely. Nexus analysis is a framework for the analysis of the affordances and constraints of communicative media as mediational means in social actions, but it can also be viewed as discourse

analysis to engage in social action. In nexus analysis, discourse is seen as 'cycling' through social actions, that is, verbal and textual tools work their way into practices, material objects, and the built environments in which we interact. (Scollon & Scollon, 2004; Norris & Jones, 2005).

As opposed to critical discourse analysis, nexus analysis focuses on micro-actions, but within nexus analysis, broader social issues are seen as grounded in the micro-actions of social interaction and, conversely, the micro-actions are the nexus through which the largest cycles of social organisation and activity circulate. (Scollon, 2001; Scollon & Scollon, 2004). Nexus analysis differentiates between discourse with a small d, which refers to language in use to enact activities and identities, and Discourse with a capital D, which refers to systems of language use and other practices that form ways of talking about social reality. Both discourses include all meaningful semiotic activity and thus are 'whole systems of the possibility of producing meanings, with or without language'. (Gee, 1992; Scollon, 2001).

In nexus analysis, discourse is seen as a form of social action and these actions are situated in time and place and the historical bodies (experiences, familiar practices) of the participants. As a long-term practitioner in product development and a short-term one in nexus analysis, I hope my perspective will bring forward some new insight. However, it is important to note that I am a participant in the nexus of practice I am studying, which means that the interests of the researcher and participants overlap. In addition, my historical body as a product design practitioner and my place in the interaction order (participants and their mutual relationships) make me privy to certain information and certainly affect my reading. (Scollon, 2001; Scollon & Scollon, 2004).

The data I am focusing on is a small sample of online content from influential actors in the community of technology business. The measure of influence is not objective but largely based on my personal experience in the community. The data is:

1. Business News Daily article "Hiring for Cultural Fit? Here's What to Look For"
2. Glassdoor article "How to Hire for Culture Fit"
3. Google "Annual Diversity Report"
4. McKinsey's report "Why Diversity Matters"
5. BCG report "The Mix That Matters. Innovation Through Diversity"
6. McKinsey report "Diversity wins. How inclusion matters"
7. Personio company website

## 3. Discourses of diversity

Already thirty years ago academics were arguing that the most important diversity variable in new product teams is function, rather than age or tenure for example. Cross-functional teams have more access to information and a wider network which helps cross-team collaboration and product transfer but agreeing on shared goals and processes was perceived problematic to performance. (Gladstein Ancona & Caldwell, 1992). Ten years later the teams were hoped to improve product quality and a few years later innovation, but again researchers failed to find evidence of the positive impact of functional diversity. (Sethi, 2002; Gebert, Boerner & Kearney, 2006). Finally, in 2017 a study showed that there is a direct relationship between functional diversity and new product creativity, but demographic diversity did not behave in the same way (Dayan, Ozer & Almazrouei, 2017).

One could argue that it is difficult for academics to unarguably prove the impact of a single factor such as diversity on fuzzy and highly contextual concepts such as quality, innovation, and creativity but curiously for example the Google study mentioned above, does not list diversity in the qualities of highly effective teams (Google Guide, 2015). The next sections will look at what kinds of discourses fuel the rhetoric of demographic diversity.

### 3.1. Discourses for diversity

In recent years, diversity, equity, and inclusion (DEI) has become a topic companies, specifically international ones, have needed to take a stand on. The topic is very complex, sensitive, even polarising, and the corporations need to tread lightly. The following examples, which are all from the Google Annual Diversity Report (2021), show how Google speaks about diversity when addressing its

employees and customers. Google is a very influential source of corporate diversity agenda because they have billions of users, over 100000 employees and they have been working on their approach for years. I call their approach the Corporate DEI Discourse.

The report starts with the following sentence:

1) *We're listening, learning, and taking action.*

By this statement, Google positions itself as an empathetic, well-intentioned student. Learning is typically mentioned as a goal in product development as it reduces the pressures of decision-making and succeeding (for example Hughes & Chafin, 1996). In this case, this is effective because the topic is sensitive and the likelihood of addressing it in a way that pleases everyone is low. One such incident took place in 2021 when Google failed to give a satisfying account of their firings of their staff scientist Margaret Mitchell and AI ethics researcher Timnit Gebru, who had called for greater diversity and inclusion among Google's research staff.

In Google's Corporate DEI Discourse, the company positions itself as a part of the society, with the people and their struggles. This is done in several different ways but specifically repeating a sentence structure where Google is in the center and expands out to the world.

2) *These issues [COVID and racial violence] deeply impacted us all, at Google and around the world, serving as a reminder that systemic barriers still hold too many back.*

3) *We recognize our responsibility to meet this moment and believe the greatest contribution we can make to changing these structural inequities is sustained action within our company, our communities, and the world.*

This not only strengthens the connection between Google and the world it occupies but can also be seen as a way of justifying actions: because Google and the world are interrelated, acting within Google will have positive outcomes also outside Google. Furthermore, the report specifies a connection between the diversity of their workforce and the inclusivity and quality of their products.

4) *Building diversity, equity, and inclusion into our workplace, products, and programs are at the heart of creating a more helpful Google for everyone. When we get this right, we ensure that everyone feels like they belong at Google and beyond.*

The example above connects the humans who build the product and those who consume the product. It backgrounds the exchange of services for profit and foregrounds universally accepted themes such as equity and accessibility.

Corporate DEI Discourse balances between the narratives of product development, corporate responsibility, and social conscience. It seeks to convince the audience of its sincerity while remaining conscious of how to reply to a public backlash if the shared agenda and its goals are not met. The vocabulary of the Corporate DEI Discourse is based on common assumptions of what is important to the current or future Google employees, who are its primary audience.

As opposed to the Corporate DEI Discourse which hid the exchange by foregrounding inclusion, Discourse of Business used in influential reports from McKinsey (2015) and BCG (2017) justified diversity with the logic of capitalism: if hiring diverse teams increases the profit margin, not hiring diverse teams is bad for business.

5) *Our latest research finds that companies in the top quartile for gender or racial and ethnic diversity are more likely to have financial returns above their national industry medians. Companies in the bottom quartile in these dimensions are statistically less likely to achieve above-average returns. And diversity is probably a competitive differentiator that shifts market share toward more diverse companies over time. (McKinsey Report 2015).*

Discourse of Business aims to convince that what is being stated is a fact. The sentence structures leave little doubt, even when words like 'probably' are used. The factual tone is reinforced with the vocabulary of statistics and the inclusion of graphs and number data to highlight the objectivity of their data and analysis. The BCG (2017) report emphasizes the vocabulary of statistical analysis to the extent that it excludes any audience not familiar with the concepts.

6) *The companies were first analyzed using the Blau index to aggregate their levels of diversity in six areas. (See the Appendix for an explanation of the statistical analysis and terms used in this report.) The resulting diversity score was plotted against each company's innovation level. We found that innovation revenue—which we define as the share of revenues from new products and services in the most recent three-year period—rises with diversity.*

McKinsey continued their reporting in 2020 with another report (McKinsey & Company, 2020) where they reiterate their argument. They state that there is ample evidence that diverse teams will be not only more creative but more resilient and more likely to bounce back from the impact. At the same time, they confess that majority of the companies they studied for their 2015 report have not followed on the path of more diversity. McKinsey continues to believe in the Discourse of Business in delivering the message, this time with an ounce more conviction bordering on religiousness:

7) *It is critical that companies ensure that there is a level playing field in advancement and opportunity, in pursuit of true meritocracy. Companies should deploy analytics tools to build visibility into the extent to which promotions and pay processes and criteria are transparent and fair. They should de-bias these processes and work to meeting diversity targets across long-term workforce plans.*

The quote shows how Discourse of Business is built on the belief of capitalism being a neutral and transparent system where everyone can have a "level playing field". It also introduces "true meritocracy" as both something that exists and is possible to achieve with the means of objective and transparent data and processes. The word "de-bias" implies that a mechanical process, not unlike that of erasing a computer hard drive, can make humans more objective and better at pursuing true meritocracy.

In addition to the business world waking up to the inequality and bias, there is more and more mainstream writing on design, products, and even medicine being developed with "the Reference Man" in mind, thus dismissing minorities such as women and people of colour. (Cleghorn, 2021; Criado-Perez, 2019; Eddo-Lodge, 2017). These voices representing different minorities coincide with the rise of intersectionality and even the design community has started to consider that we might be more biased than empathetic. Like McKinsey, the writing on product design believes in "de-biasing" either by acknowledging the bias, using a set of tools or metrics or by hiring diverse teams. The justification for the latter is the same as in the Corporate DEI Discourse: better and more inclusive end products.

## 4. Limits to diversity

While there are justifications to building diverse product teams, there are fewer actual guidelines on what it means in practice. One often referred study on effective teams is done at Google (2015) which does not list diversity as one of the building blocks. Instead, the study showed that effective teams need psychological safety, dependability, structure and clarity, meaning, and impact (Google Guide, 2015), which is reminiscent of the earlier academic writing on diverse teams as it alludes to shared ground being more important than diverse thought.

Shared ground is primarily perceived more as a practice, something that can be built within the company and more specifically in the teams but its repercussions to hiring and career advancement should be noted. There is an underlying requirement for uniformity, cultural fit, which in practice means that the employee needs to subscribe to the company values and strategy, and even capitalism if the workplace seeks profit. Or at least the employee should not actively oppose these in their daily work activity. Unfortunately, cultural fit can be very elusive and can result in biased hiring. The following sections look at a small sample of sources on how cultural fit is talked about.

Personio is a company building tools for recruiting and human resource management. They define cultural fit as:

8) *A cultural fit for your company is somebody who embodies the same values that your company embodies.*

The word "embody" here is quite key in both building a physical, cohesive actor out of the company and in posing a requirement of uniformity for the employee(s): by embodying the values of the company a person works for, they give tangible or visible form to these values. To me this conflicts with the requirement of diversity, or in the least, it sets boundaries to what kind of diversity is accepted and

where. However, it should be noted that company values are typically quite high-level and often related to ways of working. The questions Personio lists for interviewing candidates for cultural fit are also quite generic, but they do reflect the typical requirements for modern-day adaptable employees who need collaboration skills and self-reflection.

It should be noted also that Personio does not list a DEI strategy in their list of things to include in the company culture while Glassdoor, an employer branding specialist, brings up bias in hiring but does not specifically speak about diversity. Like McKinsey, Glassdoor believes in numbers as a method of preventing bias.

9)  *Fortunately, being clear on your values and deciding precisely what you need to measure during the recruitment process will prevent bias. For example, use rating scales to grade candidates' responses to culture-based questions and only use personality tests if you can justify them.*

Business News Daily's recommendation goes further to state that DEI strategy needs to be considered when hiring. The quote shows Discourse of Business but with a flavour of legal advice, which was missing from the more corporate content.

10)  *"When cultural fit is used to hire a homogenous workforce, the resulting lack of diversity will often manifest in poor creativity and undermine a company's competitiveness," Uppal said. "Focusing on hiring based on shared background or experiences may also lead to discriminatory practices."*

Based on Glassdoor research (2019), the culture and values of the organization are the main drivers for employee satisfaction (see Stansell, 2019). Business News Daily offers a solution on how to combine cultural fit with diversity:

11)  *[...] this objective is achievable when organizations have a "culture that's based on positive values that are open enough to enable a diverse selection of people to embody them in their own way."*

The above quote reflects Corporate DEI Discourse in that it offers advice on a high level without specific details which are crucial when the advice is being actioned on. The advice is based on certain accepted principles of working in corporations some of which are relatively established but others are cultural and in flux as the society at large continues to discuss equity. While Google may want to build at least a rhetorical connection between the company and the surrounding world, others prefer diverse thinking being targeted only at the work products. One famous example is Basecamp, which denied political topics from the workplace because they were deemed distracting. The decision caused an uproar, specifically because it was an active time in the Black Lives Matter movement, and while employees fled the company, the leadership held their course.

## 5. Finally

This paper aimed at contributing to transdisciplinary research by looking at a multidisciplinary practice from a transdisciplinary perspective of a researcher of one discipline and a practitioner of another. With this approach, the aim was to uncover knowledge that might otherwise fall between disciplines.

In conclusion, this discourses survey shows that although many companies have been working on the topic for some years, we are still in the early phases. On one hand, we are dealing with important topics of structural inequality and equity, which profit-seeking companies need to have a business incentive to tackle, or it will not happen. On the other hand, we are dealing with individuals, who face conflicting requirements of what or who they should be at work. The requirements are unclear, specifically as the accepted diversity is more limited than the conversation implies.

Finally, it should be noted that having diversity does not mean there is inclusion. Even if companies are pushed to make changes, the real change is likely to be slow.

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