CROWDSOURCING AS A SOCIAL PARTNER OF TRANSDISCIPLINARY PROJECTS

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Abstract

The paper explores the usage of crowdsourcing (CS) as a social partner in transdisciplinary (TD) projects, highlighting its value in stakeholder engagement, knowledge integration and social impact in sustainable development and innovation. A two-stage study was conducted, including a literature review and concept-centric analysis of 11 projects, to examine the role of CS throughout the TD project lifecycle. The research introduces a maturity model that systematises CS involvement by identifying different levels of engagement. The findings show that CS enhances the co-production of solutions, improves outcomes and broadens their dissemination through societal participation. The study provides a practical framework (model 4L) for researchers and policymakers to integrate CS into TD projects, thereby promoting social innovation and effective responses to complex challenges.

Keywords: crowdsourcing, social partner, transdisciplinary project, level of engagement, maturity model.

1. Introduction

The escalating climate and energy crises, along with increasing poverty and socioeconomic inequalities, highlight the urgent need for sustainable development [32]. A key enabler of this shift is the transdisciplinary (TD) approach to research, design, and innovations [2]. Effective TD requires the active involvement of various stakeholders in identifying issues, generating knowledge, and co-creating solutions [24]. Practical, context-specific knowledge from social partners increases the relevance and usability of TD outcomes [12]. A lack of access to such partners can significantly reduce a project's value [20].

Researchers explore strategies to improve communication and trust with social partners [26] and to clarify their role in TD [25]. An underused but promising approach is CS. Widely used in innovation, data collection and citizen science, CS enables collaborative problem-solving and public engagement. CS has demonstrated potential across various fields: innovation tasks [3], creating open-source software [29], software requirements gathering [1], and citizen science [33]. It provides access to broad expertise [15] and effectively helps problem-solving [28]. As a participatory method, it aligns well with the goal of TD to integrate societal knowledge and create new social value [31].

Despite this potential, the literature on the role of CS in TD remains fragmented and lacks a theoretical underpinning. This study addresses this gap through an exploratory, concept-centric content analysis of 11 documented TD projects involving CS, which were identified through a systematic literature review. Based on the authors' experiences in both TD and CS research, we analyse the roles that CS can play. Thus, the central aim is to explore the possibilities of CS as a TD social partner and assess its contributions. Our research responds to the limited attention given to different forms of social partner involvement in TD by posing a research question (RQ): *What roles can CS team members play in a TD project?*

The primary contribution of our study is the 4L model, which serves as a maturity model illustrating the various levels of CS involvement throughout the TD project lifecycle, ranging from treating CS as a basic data source to engaging CS fully in the TD project. This model provides a practical framework for CS involvement in TD projects, contributing to both research and practice.

The rest of this paper is structured as follows. Section 2 presents the theoretical background and motivation. Section 3 outlines the methodology. Section 4 presents study outcomes and discusses the 4L model. The final section highlights conclusions, limitations and directions for further research.

2. Theoretical background

TD is an approach that transcends traditional academic boundaries, integrating knowledge from multiple disciplines and societal actors. It promotes collaborative knowledge creation among academics, practitioners, and civil society to address complex real-world challenges. Digital technologies have become integral to this process. Digital platforms, such as communication portals, mobile apps and AI-enabled tools, are important in this respect, as they are reshaping how participatory collaboration is organised and scaled [7, 14]. CS, defined as the engagement of large, diverse groups in problem-solving or idea generation [17], fits well with the principles of TD. This section reviews the conceptual foundations of TD and considers how a digitally mediated role of CS fits within this evolving research paradigm.

TD emerged in the 1970s, building on the foundational work of Piaget [22] and Jantsch [9], and has since evolved within various contexts. Gibbons [6] characterised TD as application-oriented, socially distributed and heterogeneously organised. Pohl and Hirsch Hadorn [23] described TD as a participatory process involving diverse stakeholders, emphasising mutual learning and the integration of scientific and practical knowledge. This interpretation closely aligns with the focus of our study on achieving synergy through CS engagement. Recent approaches to participatory innovation, as discussed in the information systems literature, demonstrate the increasing incorporation of CS contributions into digital business models [10] and platform ecosystems [18]. Therefore, leveraging the digital infrastructure that accompanies CS, such as cloud platforms and decentralised technologies, can extend the reach and responsiveness of TD processes [11].

CS can be broadly defined as the process of acquiring services, knowledge or ideas from a large group of people through online collaboration [18]. In TD contexts, CS enables the recruitment of a diverse range of participants, including experts and non-specialists, to solve specific problems, provide insights and co-create knowledge. Generative AI models, machine learning pipelines, and smart contracts are now being integrated into CS platforms to optimise data flows, synthesise ideas, and ensure transparent contributions [13, 19]. This is particularly relevant in TD research, which depends on reliable, open, and inclusive IT systems. TD research is inherently dialogical and iterative. CS enhances this process by broadening participation and fostering mutual understanding [5]. Participants contribute not only data but also ideas, interpretations and local contexts, helping researchers to develop more informed and impactful solutions [16]. This aligns with Jahn's [8] assertion that balancing the influence of scientists, practitioners, and societal actors is vital but difficult and CS could help to tackle by diversifying and democratising participation.

Despite its potential, the implementation of CS in TD projects is fraught with challenges. Motivation, communication, quality control, and technical infrastructure are crucial to ensure meaningful participation [27]. Participants need clear guidance and feedback, and the project must maintain scientific rigour while remaining inclusive. This is especially relevant for CS-AI systems, where roles of human and algorithmic agents must be clearly defined to preserve trust, accountability, and transparency. In summary, while the literature on CS in TD contexts remains limited and fragmented, there is a significant opportunity to better understand and structure the role of CS in supporting TD initiatives. Our study aims to fill this gap by synthesising existing knowledge and systematically analysing cases that illustrate how CS can act as a social partner in TD research.

3. Research framework

Our study was conducted in two stages in order to address the identified research gap and answer the research question. First, we performed a systematic literature review (see Section 3.1) to identify a suitable range of TD projects for further analysis. In the second stage, we used concept-centred content analysis (Section 3.2) to describe these projects.

3.1. Systematic literature review

Our first research task was to identify TD projects that have used the CS team. For this, we conducted a systematic literature review (SLR), which provides the foundation for all subsequent analyses and helps to position research within the appropriate field [4]. In order to maintain the high quality of SLR reporting and ensure transparency when selecting papers for our systematic review, we relied on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [21].

We created a set of search terms (a query) by testing different sets of words, which would produce results that satisfied RQ. The query used to select the research sample ultimately took the following form: *['crowdsourcing' OR 'public engagement'] AND ['transdisciplinary research' OR 'transdisciplinary project' OR 'transdisciplinary approach' OR 'transdisciplinarity' OR 'transdisciplinary model' OR 'transdisciplinary team']*. Next, we decided to search for articles from 2016 to 2023 in two databases: Scopus and Web of Science. Articles from both databases were searched for according to the PRISMA 2020 guidelines.

The query yielded a total of 53 articles from both databases for the period 2016–2023. We then proceeded to organise the results into Excel using the dataset. We began by eliminating repetitive and redundant records present in both database sources, by removing nine articles. We selected only English-language articles from journals describing completed TD projects in which CS was used. In this way, we selected 19 papers for further analysis (we could not access one paper). This collection forms the basis for our further study. Having reviewed the full content of each manuscript, we determined whether it included a description of a project in which CS had been implemented. Ultimately, we identified 12 articles describing the results of 11 TD projects using CS (two concerned the same project). In this article, we explore the range of roles that can be recognised in a CS partner for TD projects, as expressed in the formulated RQ.

3.2. Concept-centric analysis of project descriptions

As an outcome of SLR, we obtained 12 research papers presenting 11 projects, which are gathered in Table 1 [1]. Based on the content of these papers, we extracted information using the concept-centric approach, as outlined in reference [30]. The selection of the analysed projects was based on accessibility criteria. Projects of this type are difficult to identify because there is no reliable sampling set to select a representative sample.

The analysis of 11 cases provides a multifaceted view of this type of project, considering the various specificities involved in their implementation. Each paper was entirely read by two authors separately. Then, they extracted information from all projects into the prepared framework for coding in line with [30]. Finally, the coding results of both authors were compared. In cases of discrepancies, the article was re-read, and the information was verified.

[1] All tables and figures are hosted on GitHub: https://github.com/Researcher524/CROWDSOURCING-AS-A-SOCIAL-PARTNER-OF-TRANSDISCIPLINARY-PROJECTS/blob/main/CS-TD%20details.pdf

4. Presentation and discussion of study results

The study results from all analysed projects from Table 1 were assigned and addressed to our RQ. We present them in the following subsections.

4.1. Scope of engagement of CS in TD projects

The study identified the following roles that CS team members may take on when implementing TD projects:

R1. CS team member – the role of using CS to create a project team. In this approach, CS is the root of searching for competencies and skills that are necessary during the project implementation. It may refer to acquiring project participants throughout the entire project development cycle or only to a limited extent (e.g. to the implementation of a single task or stage);

R2. Comprehension – the role of treating CS as a specific source of knowledge and a contextual perspective of perceiving the problem. In this way, the scientific community can deepen its understanding and look at the problem, taking into account not only the scientific or business perspective but also the social one. The involvement of CS in this role has a direct impact on the social value of the implemented TD project and the usefulness of its results;

R3. Source of data collection – a basic role and most often used in TD projects, referring to CS as a source of local, specialised and contextual data. The CS community can provide unique data that would not be possible to attain with any other approach. This role is therefore a specific way to enrich analytical and design data with a deliberately selected social context;

R4. Collaboration – as part of this role, CS is used in the context of social consultations, where the specialist knowledge and experience of people who are not direct members of the project team, but appointed as external experts with unique competencies, are sought. In this respect, CS can be perceived as an unlimited source of knowledge and skills, the use of which within a project may determine its social importance and the usefulness of its results;

R5. Co-creation – in this approach, CS participates in creating a solution to a task or problem, and its participation has a significant impact on the method, scope and shape of the emerging knowledge or product. This approach is similar to the concept of a prosumer in the production of goods and services, when the customer has an influence on the creation of products and thus "gets used to" what he will later use himself. Similar consequences arise from the role of co-creation concerning the CS participant of a TD project;

R6. Collective implementation – an important role from the point of view of disseminating and adapting the results of the TD project in the social environment. The participation of CS in the implementation stage of the project results in a reduction of the time necessary for adaptation and an increase in the effectiveness of implementation by reducing social resistance to change and shortening the dissemination time of a new solution in the social space.

Our study found that the CS approach allows one person to assume multiple roles during the research process in TD projects, which is also supported by the work of [31]. As shown in Table 2, in individual projects, it was possible to distinguish several roles (from 1 to 6) of CS team members. In the most common involvement of CS as a partner in a TD project, it is assigned around 3 roles, of which the most frequent are the collection of data sources (R3 used in 10 projects: CS01, CS03-CS11), collaboration, e.g. to obtain external expert knowledge (R4 used in 8 projects: CS02-CS09) and co-creation in problem solving or task realisation (R5 used in 7 projects: CS03, CS05, CS07-CS11). The percentage frequency of roles co-occurring for a CS partner in TD projects is shown in Table 3. It presents the proportion of co-occurrences in the set of projects. It can be noticed that the roles of R3, R4 and R5 are dominant in terms of co-occurrence in CS in TD projects. Therefore, they will serve as a foundation for formulating the maturity levels of CS partners' involvement in a TD project, as presented in Subsection 4.2.

4.2. Maturity model of CS engagement in TD projects

Our analysis of the 11 projects indicated that the involvement of CS as a partner in a TD project can strengthen various aspects of the project and also can serve as a primary objective. To sum up, we recognise the following perspectives of benefits, namely:

(1) *Analytical goal* - CS allows TD projects to tap into large, diverse groups of contributors, resulting in richer datasets. For example, CS04 utilised CS to collect macroseismic data, which is difficult to collect on a large scale. In turn, in CS05, CS of historical records helped to map racial restrictions, enabling the community to contribute directly to social change;

(2) *Enhancement* - the projects usually use CS to harness collective intelligence to classify and solve complex problems. For example, CS09 investigates how community-generated content on social media can provide insights into the sustainability of urban infrastructure;

(3) *Inclusion* – the projects aim to involve the public in scientific processes, making science more accessible. For example, CS01 aims to integrate CS team members into hydrology, enabling non-experts to contribute to scientific understanding. In turn, CS02 focuses on understanding the public's experience during the aftermath of COVID-19, with an emphasis on engagement and empowerment;

(4) *Collaboration and co-production* - CS is used in analysed projects to join diverse expertise and perspectives. For example, CS07 facilitates the co-production of research priorities on adolescent mental health, involving stakeholders from different disciplines.

Having in mind the above findings, we define four levels (model 4L) of CS involvement in a TD project (Figure 1), namely: crowdatasourcing (level 1), the acquisition and development of knowledge (level 2), project collaboration in a participatory approach (level 3) and a transdisciplinary approach with full integration (level 4).

At *level 1: Crowdatasourcing* - CS is treated as a source of local data, access to which in this approach is the fastest, most effective and guarantees the highest reliability of access and data collection. The role associated with this level of involvement is R3 (Source of data collection). Level 1 is a foundation based on a network of volunteer data collectors, and this data could also be applied to the next three more advanced levels.

At *level 2: Knowledge acquisition* - the CS community brings its own local knowledge and individual cognitive abilities to analyse problems during the implementation of the project. The knowledge acquisition level, therefore, perceives the CS team as a source of unique local knowledge, characteristic of a specific community identified in the targeted approach. The condition for moving from level 1 to level 2 is therefore to recognise the value of the CS partner's knowledge and/or to incorporate it as a resource and/or product of CS in TD project implementation. The roles at this level include R2 (Comprehension) and R4 (Collaboration). The CS partner acts as a consultant and external expert, aiding in the understanding of the problem and ensuring that the social context is properly taken into account when developing a solution. At this level, the CS partner can also act as a data provider (R3), particularly if it establishes a contextual understanding of knowledge and the problem at hand. Activities at this level should be supported by internal systems tailored to foster two-way, discussion-based cooperation, enhanced by discussion forums and prompt feedback.

At *level 3: Participatory approach* - there is a significant change in the perception of the CS partner compared to levels 1 and 2. Whereas at earlier levels they were mainly a valuable source of information resources, at level 3, the CS partner becomes a member of the project team and their involvement in the project is significantly deepened. At this level, the contribution of the CS community is characterised by its involvement in many phases of the research process, which positively influences the social value of the implemented project and the usefulness of its results. The participatory nature of this level indicates involvement in identifying and understanding the problem and influencing the approach to solving it. The level considers the involvement of CS as a member of the project team in selected stages of project implementation. In most cases, these are the stages of understanding the problem (Comprehension) and collecting data (Source of data collection). The main roles associated with this type of involvement are therefore R1 (CS team member), R2, R3 and R4. It is at this level that the effects associated with the deepening of the societal impact and the creation of a new CS role in TD project culture begin to emerge. To achieve these results, it is necessary to integrate a dispersed team by creating an environment that fosters collaboration, design and communication. This environment must be flexible and user-friendly for different user groups.

The highest form of engagement is the *Transdisciplinary approach (level 4)*, which considers full TD integration and assumes the participation of all CS roles throughout the entire course of the TD project. Hence, all the roles identified in Subsection 4.1 are characteristic of this level. However, the most important are R5 (Co-creation) and R6 (Collective implementation), which position the CS team as an active participant in the process of producing and disseminating TD innovations. Thus, significantly increases the CS partner's responsibility for project results. At level 4, CS team members can be called social scientists who participate intensively in all phases of the project, contributing to a better understanding of complex problems and the development of practical solutions with higher social utility. Projects implemented in this approach have a chance to generate and transform new knowledge of significant social and scientific importance. However, achieving this level is quite challenging. It requires building a full-stack innovation ecosystem with AI-enabled orchestration, decentralised governance, integration of social media and sensor data, supporting real-time feedback, version control, traceability, and peer-to-peer validation. It also requires building a project culture based on mutual respect, understanding and recognition of the value of diversity. These are challenges that most TD projects face, but they are particularly demanding in the context of CS partner participation.

5. Conclusions

TD projects and initiatives often struggle to establish purposeful and effective collaborations with social partners. It is difficult to identify the right participants because they are not based in an institution or organisation where the connection is known. In such cases, CS is a useful mode for finding, identifying, and contacting potential participants in a TD project. In this context, the article contributes to further research on the inclusion of CS in TD projects, highlighting its roles and the possibilities it offers. Our study confirms that CS provides innovative ways to collect and utilise data characterised by local community knowledge in support of knowledge creation and decision-making. CS should form the basis for recognising the views of stakeholders in a TD process that requires a collective understanding of the issue. Thus, both approaches (CS and TD) complement each other. Our 4L model conceptualises the phases and clearly distinguishes the role evolution of a CS partner in a TD project.

This raises the question of the value of such a design approach. From the perspective of the analysed projects, it can be said that CS enhances the appeal of TD activities. Above all, the involvement of the CS partner is a response to the constraints and barriers faced in seeking societal involvement in TD projects. Involving the public as a wide-ranging partner in scientific research, as CS does, empowers society and broadens education on complex issues. This, in turn, accelerates knowledge transfer and public awareness. The CS partner also brings diverse perspectives and expertise, often leading to innovative solutions that might not emerge within a single discipline or homogeneous research environment. From an analytical perspective, CS enables projects to collect data and information on a scale that would otherwise be impossible. Finally, from an organisational perspective, CS can reduce the financial burden of research projects by harnessing the efforts of volunteers.

Our study has limitations that need to be mentioned. Firstly, the relatively small sample size is one of the main limitations of this research. While this number of projects is suitable for qualitative content analysis, it limits the generalisability of our findings. Secondly, we did not conduct any empirical research ourselves to validate our findings in practice in this study, but we plan to do so in future. Thirdly, our research focuses exclusively on TD projects from the literature (2016–2023) found in Scopus and WoS that included the CS team. Therefore, we may have overlooked other valuable projects in different databases. These limitations do not affect the accuracy or correctness of the 4L model. However, they restrict the level of detail that can be provided regarding its characteristics, conditions, and limitations. To further improve the model, focused empirical research is necessary.

Our study also makes some important contributions. Firstly, it adds to the growing body of literature on the use of CS in TD projects, shedding light on the various roles it can play when collaborating. Second, we introduce the 4L model. Our research fills the gap in the literature concerning frameworks that capture CS development levels within TD projects. This work is the first to conceptualise the application of CS in such projects. As the research results demonstrate, the effectiveness of a TD project hinges on the adequacy of the level and extent of CS involvement in the project's needs and requirements. Therefore, the conditions and limitations of this cooperation should determine the direction of further research on the 4L model. Thirdly, our findings can serve as helpful guidelines for scientists and managers conducting projects with a CS partner, provided they are first verified through empirical research.

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