User theory for inclusion or exclusion? Conceptual models to address the role of users for inclusive socio-technical change[1]

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ABSTRACT

Innovation Studies (IS) and Science, Technology and Society studies (STS) explored the role of users in socio-technological change: from their role as consumers, adopters or experimenters to maximize profit, to exploring the mutual shaping of users and technologies and the power relations embedded into the process of use. By the turn of the century, amidst broader claims to democratize Science and Technology, scholars and practitioners explored the ways technologies may contribute to overcome social, material, and political restrictions in structural inequality scenarios. While discursively praising user inclusion as a 'good practice', 'technologies for inclusive development' (TID) ranged from processes of distributed decision-making and empowerment to paternalistic schemes and unwanted effects that reinforce exclusion patterns. This paper aims to revisit user theories through the lens of inclusion/exclusion to explore user engagement in TID initiatives to understand the relation between user involvement and 'inclusive' outcomes. We argue that diverse theoretical views on user-centeredness, which we systematize in 5 types, are tied to different normative assumptions about what user-centeredness is for, with implications for technology practice and STS theory. In interaction between literature review and instrumental TID case studies (in water, health, nutrition, and recycling), we examine how these differences lead to differential outcomes in terms of inclusion (e.g., exclusion problem-solving, distribution of benefits, social learning). In turn, we analyze how bringing the inclusiveness/exclusion dimension may help to reveal user literature blind spots that need to be addressed, and how unveiling user theory may contribute to deepen our understanding of inclusion in technology making.

Keywords: User Theory; Technologies for Inclusive Development; Inclusive Innovation; Participation in Science and Technology; Technology Governance; Critical Studies of Innovation.

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INTRODUCTION

In the last 40 years, Innovation Studies (IS) and Science, Technology and Society studies (STS) explored the role of users in technological change. Linearly, early approaches sought to understand their role as consumers and adopters, their capacity to experiment and create (von Hippel, 1976, 1986, 2009; Schot *et al.*, 2016), or their interactions as learning processes to gain profit in capitalist firms (Lundvall, 1988). Meanwhile, critical literature increasingly brought power into the use, analyzing with what users do to technologies (how they reshape, reconfigure, and resist them) and what technologies do to users (how users emerge, become transformed or suppressed?) (Oudshoorn & Pinch, 2003; Kline & Pinch, 1996).

With the turn of the century, academic consensus to democratize technology gained momentum (Kleinman, 2000; Jasanoff, 2005; Invernizzi, 2020). On the practitioner side, rising trends on user-centered innovations in technology design (Norman, 1988; Abras, Maloney-Krichmar & Preece, 2004) tended to equate taking users into account as 'user inclusion'. Simultaneously, scholars and practitioners explored how technologies may contribute to overcome social, material, and political restrictions in structural inequality scenarios. While discursively praising user inclusion as a good practice, 'technologies for inclusive development' (TID) ranged from processes of distributed decision-making and empowerment (Carenzo, 2014; Bortz & Thomas, 2017) to user-excluding paternalistic schemes. Even when imbued in inclusive intentions (Heeks *et al.*, 2014), their outcomes ranged from participatory scaled-up technology policy programs (Bortz & Thomas, 2017) to their failed and unwanted effects that reinforced patterns of exclusion (Dias, 2013; Thomas *et al.*, 2017). TID initiatives as quasi-experiments become thus privileged settings to dive into the socio-technical relations between users, producers, and artifacts, where empowering actors and making technologies work to provide access to basic goods (health, food security, housing, energy supply, education) becomes most needed.

This paper aims to revisit user theories through the lens of inclusiveness/exclusion and to explore user engagement in TID initiatives to understand the relation between user involvement and 'inclusive' outcomes. We argue that diverse theoretical views on user-centeredness are tied to different normative assumptions about what user-centeredness is for, with implications for technology practice and STS theory. We examine how these differences lead to differential outcomes in terms of inclusion (e.g., exclusion problem-solving, distribution of benefits, social learning) and, in turn, how bringing the inclusion/exclusion dimension may help unveil user literature blind spots that need to be addressed.

Research is based in a qualitative methodology of literature review and instrumental case studies. First, we present the problem of users for social inclusion. Second, we review IS and STS user theories through an inclusion/exclusion light, under the dimensions of power, gender and knowledge flows. Third, we present four TID case studies (in water, health, nutrition, and recycling sectors) that will allow testing and critiquing existing approaches, understanding users in and beyond market dynamics in a territorially grounded basis. In interplay between theory and practice, the discussion presents a typology to understand exclusion and inclusiveness in user theory. The paper ends presenting six critical implications that may serve to expand user theory and inclusive practice towards more meaningful socio-technical citizenships.

METHODOLOGICAL APPROACH

Research is based on interplay between literature review and instrumental case studies. Since 2010, we surveyed over 100 cases of TID in the health, water, food, waste, energy, and housing sectors in Argentina (Thomas *et al.*, 2017), and 66 cases specifically in biotechnology (Bortz, 2017).

We selected four cases in the fields of water, health, nutrition, and recycling, showing an incremental path in user involvement in technology design. These allowed testing user theories along extensive empirical trajectories, mapping changes in the user-producer-technology interactions, and their implications for inclusion/exclusion.

The case studies involved:

a) Identification of relevant actors through snowball techniques.

b) In-depth interviews with researchers, technicians, users, policy-makers, and producers: Case 1, 3 interviews supplemented with audiovisual material developed by the research group; Case 2, 10 interviews; Case 3, 13 interviews; Case 4, based on secondary sources that account for an over 10-year research-action ethnographic work (published in Carenzo, 2014, 2017), supplemented with an additional interview.

c) Documentary analysis based on primary and secondary sources (projects, government documents, news, papers, etc.).

d) Participant observation in meetings and kick-off workshops (Case 2, 4), non-participant observation in laboratory and governmental facilities (1, 2, 3), exhibits (3, 4), and schools (3).

Results presented in this work originated in an inductive process, in iterative feedback between empirical data and TID and user theory contributions.

Users in technologies for inclusive development

Since the 1960s, scholars and activists experimented with alternative technological dynamics towards diverse understandings of socially inclusive and environmentally sustainable societies. These experiences can be collectively addressed as 'technologies for inclusive development' (TID). They involved a range of actors (R&D units and universities, social movements, cooperatives, NGOs, governments, development agencies, companies, foundations) to develop responses to poverty, mainstream patterns of industrialization and mitigating its unwanted effects.

From a critical stance, Mumford's 'democratic' or 'authoritarian' techniques (1964) linked technology design, exertion of governance and control, technology production, appropriation, and use, and how they enable certain human alternatives. In the 1970s, new grassroots movements emerged articulated with activist scholarship (Fressoli *et al.*, 2014). Naming themselves as 'appropriate', 'intermediate' (Schumacher, 1973; Willoughby, 1990; Herrera, 1981), 'alternative' technologies (Dickson 1974) or, in the 21st century, 'grassroots innovations' (Gupta *et al.*, 2003), 'social technologies' (Dagnino, 2010), they aimed to respond to community development problems, through goods, services and technological alternatives to scenarios characterized by poverty and lack of access to basic goods in rural, urban and peri-urban areas (Fressoli *et al.*, 2014).

In the early 2000s, the innovation imperative (Pfotenhauer *et al.*, 2019) sprung up into scene, introducing a managerial gaze into creating and scaling-up technologies for social inclusion, shaping the notion of inclusion in turn.

Presented as remedies for the undesired exclusive effects of innovation, 'X-innovations' (Gaglio *et al.*, 2019) permeated development policies, traveling across developing countries: 'social innovation', diverse alternatives based on (social) entrepreneurship, NGOs, foundations, and corporate responsibility; 'bottom of the pyramid' (BoP, Prahalad, 2010), focusing in large companies developing and distributing products for the poor; 'frugal/Jugaad innovation', creating affordable goods with substantial cost reduction (Soni & Krishnan, 2014); 'below-the-radar innovation', focusing on local small and medium companies developing BoP markets in informal settings (Kaplinsky, 2011; Chataway *et al.*, 2014). In Latin America, especially in Argentina, Brazil and Uruguay, socially oriented public R&D prevailed, based on the commitment of public universities and research institutions within their territorial context (Bortz, 2017).

However, the way users are visualized, in what capacities they engage in TID, and how this shapes the outcomes of TID initiatives and -ultimately- what 'inclusion' might be, has not been addressed. We show that the normative assumptions on the role of users and how they are to be engaged, leads to different paths in terms of

inclusion outcomes (the possibilities for adopting and using the 'inclusive' technologies, the distributional of benefits from situated technology development and social learning). These enquiries lay within a broader concern on the relation 'participation–inclusion' in TID and broadening the governance over technological decision-making as a dimension of our world-making.

In previous works we stylized a background tension between the two ways the 'participation–inclusion' relation has been addressed in TID initiatives (Bortz & Thomas, 2017). These disclose the orientation and object as framed by policy actors, scholars, and activists:

(a) *Inclusion as a result*. They aim to give access to goods and services by broadening consumption capacities, expecting a positive impact in the livelihoods of excluded groups. From solar panels in rural locations, cell phones for financial inclusion, to functional foods to prevent starvation, these projects are conceived as top-down specific technological fixes for specific deficits (Fressoli *et al.,* 2014; Thomas *et al.,* 2017; Hanlin & Murguri, 2009; Foster & Heeks, 2013). Users are considered beneficiaries or end-of-pipe consumers (usually framed as those living below X-income level); technology is developed by experts and transferred to users. Even when discursively praised, actor involvement beyond expert authority tends to tokenism, limited to being a source of information on their needs for producers, or circumscribed to late stages of technological development (testing, using, adapting, repairing, brokering), hindering more substantial capacity building. Their decision-making stays limited to a consumer framing (mainly, using, purchasing and rejecting options). As the focus is placed on producing and giving access to goods, this approach enabled scaling-up TID policy programs (Dias, 2013; Bortz & Thomas, 2017; Benitez Larghi, 2020).

(b) *Inclusion as a process*. They aim to generate inclusion by involving neglected actors and communities in the processes of problem framing, technology design, development, and solution delivery, promoting distributed technology governance. The focus is not on specific artifacts, as they serve as a driver to engage these actors, foster local capacity building, and build technological situated adequacy (Thomas *et al*., 2017). As socio-economic exclusion intersects with epistemic inequality, user inclusion aims to facilitate territorially embedded social learning, and to empower actors to shape the living conditions that matter for their own well-being. This type presents many forms, from the recovery of indigenous knowledge, user participation in problem framing to co-design initiatives (Peyloubet, 2011). Here *inclusion* gains a broader scope, understood as 'equalizing rights, dignifying the conditions of human existence, generating new spaces of freedom and justice, improving the quality of life, and equitably distributing wealth' (Thomas & Santos, 2016).

This assumes the co-construction of users and technology as two sides of the same socio-technical relation (Oudshoorn & Pinch, 2003; Thomas, 2008). We explore the role of users in TID, their involvement in technology governance, and how this shapes TID in turn, the relations of epistemic authority they entail, and their inclusive/exclusive outcomes (Jasanoff, 2005). We understand participation as praxis in a contested ground, where 'the ability to influence techno-cognitive decision making' is at play (Bortz & Thomas, 2017). Actors exert their agency according to their interests, motivations, capacities, ideologies and possibilities in a territorially situated interplay with other involved actors (Bortz & Thomas, 2017).

Far from linear and a-conflictive visions, we will see how tensions, power asymmetries and the assumption of who the user is (or should be) becomes embedded into TID designs, shaping users and modifying the distribution of benefits and privileges. 'Users' are not understood as an abstract fixed category, but as a locally embedded contested one, assigning roles, self-attributing roles and marking who and how makes the decisions when inclusion/exclusion dynamics are at stake.

UNDERSTANDING USERS AND NON-USERS: A REVIEW

Users in innovation studies

Traditionally, technology analysis, focused on its design and production, rarely analyzed what users did with it. Actors and contexts of production and of use appear polar opposite, at each end of the development pipe (Oudshoorn & Pinch, 2003; Stewart & Hyysalo, 2008), limiting users' agency to a use/reject choice.

In the '1980s, the urge to maximize profit through user adoption rates, Innovation Studies started to analyze users-consumers, seeing knowledge on their needs as new technical opportunities (Lundvall, 1988). Von Hippel's (1976, 1986) pioneer works found that the more novel and useful innovations were developed by users to solve their daily practice problems. These 'lead users' (von Hippel, 2009) emerge in 'sticky information' contexts. The information asymmetry between users and producers results in user innovation to be more useful when problem-solving takes place in the same context where problems occur (1994).

This scholarship focused in design stages, disregarding how users use technologies. Users were praised for the knowledge they possess on their own needs and problem-solving capacity. Conversely, 'user-producer' relations (Lundvall, 1988; Johnson, 2011) sustained the division between users and the firm. It observed users, their needs and skills for product improvement and subsequent adoption. These works preserve users in their consumer role (attributing them knowledge on their needs),

but transcends into late stages of technology development, monitoring changes and new opportunities through user-producer interactive learning. Later works studied how knowledge from multiple actors (intermediaries, intermediate, final users) flowed into iterative and gradual innovation process (Kline & Rosenberg, 1986; Stewart & Hyysalo, 2008) through learning by using and interacting (Lundvall & Johnson, 1994).

From the design's end, new trending concepts arose, such as 'user centered design'. This focused on 'proxy users' (representing an average end-user and their needs), neglecting actual users and their contextual specificities. Focusing on later stages of technological development, concepts as 'innofusion' (Fleck, 1988) gained traction, depicting what happens on user-sites, where user-producer relations are not necessarily collaborative or coordinated. This concept was applied by inclusive innovation literature to depict the link between an invention and its widespread adoption by low-income consumers (Foster & Heeks, 2013). With the increased interest in citizens as renewable energy end-users, concepts such as 'active/inventive users' stressed the do-it-yourself (DIY) variations and adaptions conducted in user's homes (Hyysalo *et al.*, 2013).

Recent works explored how users create spaces and opportunities for technology appropriation. Assuming knowledge asymmetries, 'innovation intermediaries' or 'intermediate users' (Stewart & Hyysalo, 2008) serve as gatekeepers, configuring and facilitating technologies (e.g., learn, filter, translating information), and brokering between users and suppliers, and therefore reinforcing the use-side vs. supply-side analytical divide.

Either focusing on the design or adoption, these theories reinforce market assumptions on the ontological and spatial divide between suppliers and users and the linearity of technology development. They show how users modify technologies, not depicting how they are shaped in turn. Users' specificities remain blackboxed, hindering knowledge asymmetries, and context-sensitive features, including gender and intersectional power asymmetries.

Transition theory

Drawing upon IS and history of technology, transitions theory (TT) seeks to explain large-scale and long-term socio-technical change, as the result of the coevolution of elements in three levels: niche, regime and landscape (Geels & Schot 2007). It explored the biases in users' choices to unsustainable energy practices and their role towards sustainable transitions (Smith *et al.*, 2010; Schot *et al.*, 2016).

Initial works analyzed users in niche markets, where deep learning takes place (Truffer, 2003). Schot, Kanger and Verbong (2016) systematized diverse types of users in transitions: 'user-producers' and 'user-legitimators' creating technological and

symbolic alternatives in early stages, experimenting with radical technologies, and shaping the values and worldviews of niche actors, respectively. To accelerate niches, 'user-citizens' (e.g., activists and grassroots movements) mobilize against existing regimes, to scale-up alternative niches (Smith *et al.*, 2010). Meanwhile, 'user-intermediaries' broker between actors, building networks and conditions for technology appropriation (Stewart & Hyysalo, 2008). As regimes stabilize users become passive, narrowing decision-making to consumption ('user-consumers') (Truffer, 2003).

This approach places the creation and reproduction of collective routines at the center of the analysis, in a co-evolutionary process driven by endogenous interactions between technologies, user preferences and institutional frameworks. User's agency becomes critical for niche building, to the point of blurring the supply/demand divide but remains constricted by structural power in stabilized regimes. The innovation studies imprint in transitions theory preserves its universal user framings, linear trajectories, and oversees the way users are transformed by technology. The approach tends to neglect inclusion/exclusion dynamics, gendered and class biases, even assuming certain purchasing power and taking for granted the possibility of (not) choosing between competing technologies.

The gendered 'user turn' in STS

In the early '70s, early socio-historical STS studies questioned the role of users in technology. From a gendered perspective, Schwartz Cowan (1976, 1987) spotlighted neglected spaces (the household), actors (users, women, mothers) and technologies (domestic appliances) to explore the effects of technological change in household dynamics and gender roles. The 'consumption junction' (1987) brought out the adoption site, consumers' agency and networks, and how they negotiate practices and meaning in ordinary technology use.

Feminist studies aimed to capture user diversity and power relations in technological development (Oudshoorn & Pinch, 2003), departing from dichotomous sides (user-producer) towards multiple perspectives in contested sites. Bringing specificity into this multiplicity defies 'default user' approaches and stresses power asymmetries in user roles: e.g., differentiating 'end users', affected downstream by innovation, 'lay end-users', excluded from expert discourses, and 'implicated actors', whereas absent but targeted by others or physically present but silenced/ignored (Casper & Clarke, 1998).

Early feminist user studies emphasized women's absence in traditional technological accounts. They contest their focus on design and production, the gendered division of labor, and how the adoption of technologies for disempowered groups relies on the acceptance by actors in power, disregarding its convenience for

end-users (Schwartz Cowan, 1987; Casper & Clarke, 1998; Maines, 2001). They also heighten neglected women roles in socio-technical change: as technology appropriators, silenced as 'implicated actors', through scholarship on neglected quotidian objects (from home appliances to reproductive technologies), or new politicized entities where user emerges as a hybrid of machine and organisms (Haraway, 1995).

Semiotic approaches: configuration and (gender) scripts

Since the 1990s, semiotic approaches have drawn attention to the ways designer's representations on users became imprinted into technological objects. Woolgar's 'user configuration' (1991) showed how designers constrain user's agency through design. Despite acknowledging power relations, this depicts expert governed one-way flows and oversees that designer's agency is also restricted by wider power dynamics.

Latour (1998) and Akrich (1992) deepen how designers define users; anticipate their interests, abilities, motivations and behaviors, 'programming' a set of (power) relations are into technologies. These 'scripts' inscribe designer's visions and delegate responsibilities to users and artifacts, defining courses of action between actors, spaces and technical objects. If users' action 'program' conflicts with the designers' program (or contrariwise), resistance or 'anti-programming' actions make take place (Akrich & Latour, 1992).

Contributions by feminist scholars elaborated on 'gender scripts', the inscription and de-scription of gender representations in technology as enabling/inhibitors of gender relations and practices, inscribing these power relations of inclusion/exclusion (van Oost, 2003). They showed that when building gender-neutral technologies ('user-as-everybody'), the designers unconsciously inscribe their own, masculine biased preferences ('I-methodology'). Masculine gender scripts limit users' choices creating unequal distribution of benefits and privileges (Rommes *et al.*, 1999; Oudshoorn *et al.,* 2004).

These frameworks envisage users as active participants, in a reciprocal object-subjects relationships. However, they were questioned for sustaining the design/use divide, preserving the innovation linearity, and by its focus on 'experts', representing users as 'disempowered' (Oudshoorn and Pinch, 2003). For instance, the notion of 'anti-program' opposed to the designers' will, fail to capture users' repertoires and sense-making (Sørensen, 2016).

The social construction of users and non-users

Social constructivism conceived users as a relevant social group shaping technology in early stages of design – even as resisters (Pinch & Bijker, 1984; Bijker, 1995). Later works on users as agents of socio-technical change reopened interpretive flexibility after closure and in users' context, defying designers' constraints. These deepened the way user's identity became transformed in use, along with social and power relations (using practices, gender roles, territories, economic structures) (Kline & Pinch, 1996; Pinch, 2003).

Deepening on choices of resistance and non-use as essential for socio-technical change, this scholarship questions the rhetoric of progress that assumes the desirability of new technology adoption (Kline, 2003; Kline & Pinch, 1996). Drawing from Bauer (1995), Wyatt's (2003) typology of 'resistant', 'rejecters', 'excluded' and 'expelled' opens the black-box of 'non-use' beyond deprivation ('non-access' or exclusion), including choices of 'passive avoidance' and active resistance as self-affirmation.

Cultural studies: consumption and domestication of technology

Focusing on the user-consumer, cultural studies (CS) addressed the role of consumption in shaping cultures and identities. With 'domestication' practices (Silverstone *et al.*, 1992; Lie & Sørensen, 1997) this approach captures the symbolic, material, and cognitive dimensions of selecting, adapting, resisting and/or integrating new technologies into daily routines (Sørensen *et al.*, 2000), transforming users, power relations and technical objects in turn (Oudshoorn & Pinch, 2003). Even when sustaining a user-producer divide, CS contests designer's epistemic authority and control over users' agency, focusing on users' spaces (home, work, leisure) as analytical loci.

They criticize IS understanding of learning as 'honing of skills', as it conceals power and conflict relations. Here 'social learning' as a mean for technology domestication becomes the basic element of sociotechnical change (Sørensen, 1996), driver and outcome of sense -making and changes in political structures (Lie & Sørensen, 1996).

Opposed to universalist understanding of users and designs, CS stress the spatiality and timeliness of using and learning practices, exploring trajectories, and how technologies are made to work (or not) when being displaced to new local contingencies. This dismantles the linear concepts of 'diffusion' as a 'passive act of adaption and adoption' (Sørensen, 1996, p. 6) and 'technology transfer', arguing the insufficiency of disembodied knowledge ('knowledge has either to be embodied – transfer of people as well as technology – and/or to be developed locally through

learning') (Sørensen, 1996, p. 6). 'Local experts' in social learning are thus essential to build competence and enthusiasm in context-sensitive implementations (Faulkner & Lie, 2007).

Acknowledging the multidimensionality of exclusion and the importance of local specificities, CS reckons that inclusion strategies require 'effective tailoring' with heterogeneous measures package, beyond 'making technology available', and awareness of the specificities of excluded groups, their needs, and how to reach them (Faulkner & Lie, 2007, p. 173).

Activist streams: Design Justice

Design Justice (DJ) brings together semiotic approaches, feminist scholarships with co-design and participative research-action approaches. As an analytical approach, it focuses on how designs manifest/reproduce/challenge the 'matrix of domination', i.e. intersecting inequalities (race, class, and gender) as interlocking systems of oppression that exclude disadvantaged populations. As a social movement, it seeks a more equitable distribution of the risks, benefits and burdens of design, meaningful participation in design decisions, and recognition of community-based design traditions, knowledge, and practices.

DJ criticizes universalist designs as they erase certain groups and the bias of 'inclusive' designs structured around a single-axis framework (race/class/gender). They explore how designs encode particular value sets and uses ('affordances'), what uses they hinder ('disaffordances'), and how they force users to alter their identity to enable access ('dysaffordances').

DJ claims for participatory design as a driver for community empowerment and an equitable distribution of benefits. This requires (a) prioritizing the voices of those affected by the design over the designers' intentions; (b) decentering 'experts' as facilitators; (c) broadening the understanding of expertise, including experiential knowledge, seeing 'designers' in people and forms of expertise mainstream theory has erased; (d) keep design collaborative and accountable, controlled by the community, aiming at 'the full inclusion of people with direct lived experience of the conditions the design team is trying to change' (Constanza Chock, 2018, p. 9-10); (e) seeking local adequacy, looking at working solutions within the community, recovering indigenous, and local knowledge and practices (Constanza Chock, 2018). DJ is thus procedural and distributive, observing inclusion as justice in the processes and results of design. This includes matters of equity, beneficiaries, values, design sites, ownership and accountability.

Systematization

Table 1 systematizes the literature review, presents its key concepts. It focuses on the phases of technological development they pivot from, the shaping of user-technology relations, their understanding of power relations, their uptake into gender perspectives, and basis for inclusion/exclusion.

Table 1. Systematization of IS and STS user theory approaches

Theoretical approach	Authors	Key concepts	Phase of technology development	User-Technology Relation	Power relations	Gender perspective	User Inclusion/ Exclusion
Innovation Studies	Lundvall	User-Producer relations	The whole process	User → Technology	No (conflict suppression)	No (universal male)	Profit from knowledge on user's needs
Innovation Studies	von Hippel (1976, 1986, 2005)	User innovation / Lead users / Democratization of technology	Iteration until design stage	User → Technology	No (conflict suppression)	No (universal male)	Profit from knowledge on user's needs due to information asymmetries
Innovation Studies	Hyysalo, Juntunen, Freeman (2013), Stewart & Hyysalo (2008)	Active / Inventive users, Intermediate users	Design and adaption	User → Technology	No (conflict suppression)	No (universal male)	Facilitate technology appropriation
Transition theory	Geels & Schot (2007), Truffer (2003), Schot, Kanger & Verbong (2016)	User-producers, user-legitimators, user-intermediaries, user-citizens, user-consumers	Niche building User-consumers in the regime	Users → Technology (transition) Technology → Users (Acknowledged, not explored)	Yes (Structural power in the regimes, agency and micropolitics in niches)	No (universal male)	Technology experimenters and niche builders

History of Technology	Schwartz Cowan (1976, 1986, 1987)	Consumption junction	In consumption/use	(1976) Technology → Users (users do not modify tech) (1987) Technology ↔ Users (users modify technology through consumption choices)	Yes (micropolitics)	Yes	Recover neglected spaces, actors, and technologies
Symbolic interactionism/ Gender studies / 'Arena analysis'	Casper & Clarke (1998)	End users (patients), and 'implicated actors'	Use and adoption	Users ↔ Technology (multiple arena-shaping)	Yes (power asymmetries, gender division of labor)	Yes	Stress diversity and power asymmetries
Actor Network Theory / Semiotic Approaches	Latour (1990) & Akrich (1992)	Programming / Scripts Anti-programming	Design Use, constrained by designers	Users ↔ Technology (co-construction)	Yes (semiotic power)	No	Power relations inscribed into material designs, Actions of resistance
Semiotic Approaches / Gender studies	van Oost (2003), Oudshoorn, Rommes & Stienstra (2004)	Gender scripts, I-Methodology, 'user-as-everybody' / 'man by default'	Design	Users ↔ Technology (co-construction)	Yes (semiotic power)	Yes (gender inscriptions, gender roles)	Gendered power relations inscribed into material designs
Social Construction of Technology	Pinch & Bijker (1984) Kline & Pinch (1996)	Users as Social Relevant Groups (1984) Users as agents of technological change (1996)	Interpretive Flexibility and Closure The whole process (especially, after closure)	Users → Technology Users ↔ Technology (co-construction)	Yes (micropolitics and semiotic power)	Partially Yes (gender roles)	Drivers of socio-technical change, questioning 'progress' as adoption
Social Construction of Technology	Sally Wyatt (2003)	Non-use(rs): resisters, rejecters, excluded, expelled. Have-nots, Want-nots.	Use and consumption	Users ↔ Technology (co-construction)	Yes (micropolitics and semiotic power)	Yes (user diversity, gender roles)	Questioning 'progress' as adoption, non-use as exclusion or self-affirmation

Cultural and media studies	Lie & Sørensen (1996), Sørensen (1996), Faulkner & Lie (2007)	Domestication, Local experts, Social learning	Consumption and use, secondarily design	Users ↔ Technology (sociotechnical change by domestication/social learning)	Yes (multi-dimensional inclusion/ exclusion, local conflict)	Yes (intersectionality)	Transformations in culture and sense-making, local appropriation
Gender studies / Semiotic studies / Co-design	Design Justice (Constanza Chock 2020)	Affordances, disaffordances y dysaffordances	Design (as iterative process)	Users ↔ Technology	Yes ('matrix of domination': patriarchy, racism, colonialism, capacitism in design)	Yes (intersectionality)	Inclusion as justice: equitable distribution of the benefits and burdens of design, equitable participation in decision-making, values accountability

Source: own elaboration (Bortz & Thomas 2022).

SHAPING USERS IN TECHNOLOGIES FOR INCLUSIVE DEVELOPMENT

In the following sections we will present a set of four TID case studies, showing how users/non-users shape/are shaped in technology development.

Case 1: Biosensor for arsenic detection in water

In 2013, an interdisciplinary group at the University of Buenos Aires intended to develop a low-cost biosensor to detect arsenic in groundwater. Being one of the main deficits of access to basic goods in Argentina, limited access to safe water is associated with chronic disease and food contamination.

An interdisciplinary 16-people group of chemistry, biology, IT, and physics researchers and students from a public university gathered to develop a project for a synthetic biology competition. The actors aimed to promote open and collaborative technological production as part of their social commitment. Based on a literature review the technologists framed the problem as the presence of arsenic in consumption water and the high exposition of Argentina's population (10%, 4 million people) to the pollutant. Built on epidemiological data, end-users were conceived abstractly and in universal terms (addressed in the interviews as 'affected population', 'the people', 'people who consume water with arsenic', 'general public' or 'people who need it'), detached from territorial context (Bortz, 2017).

Working with synthetic biology, the designers prototyped a detection kit based on the genetic modification of *E.coli* bacteria. The project was awarded the competition's gold medal. In 2014-2015 they attempted to build a second prototype, incorporating a team of industrial designers, considered key to 'start thinking about users' (interview).

Since 2014, the team attempted to build the viability of the biosensor 'outside the lab'. First, they sought funding to develop the prototype and increased its visibility through innovation awards, grants and media coverage. Second, they explored new management alternatives that may allow a scaled-up production. Third, they looked for water samples to test the prototype. This activity let some informal approaches to potential users and affected population. Here, contact with users, whether individuals (end users), municipalities, or NGOs (potential intermediate users or adopters), manifested as sporadic and informal conversations. These broadened the understanding of the researchers of the arsenic problem but did not modify the design. Gender roles related to water management (Cleaver & Hamada, 2010) did not appear into consideration.

In 2015, the core-group tried to become a start-up. This redefined the participants: many volunteers left, the group narrowed to a 3-people team led by the main researcher, an industrial designer and a biologist. In recent years, new alliances

were forged, exploring the device's potential to detect other metals in water. Despite this trajectory, even when the biosensor managed to gain visibility 'outside the laboratory', it has not been manufactured, scaled-up nor adopted by end-users nor by intermediate-users (firms, water suppliers, etc).

This case shows a TID trajectory framed under an 'inclusion as a result' approach. It emerged with a participatory discourse but remained an experts' design. The solution was framed as a specific technology fix, designed in universal terms for an undefined territory and abstract users. Users, affected population (potential 'user-consumers') or industry/governmental allies ('intermediate users', 'adopters') were not contacted until the late stages, having no influence over technological design. User-producer relations (Lundvall 1988) were hardly established, in a classic linear innovation scheme. The design was set under an 'I-methodology', configuring the 'user as everybody' (Oudshorn, Rommes and Srienstra 2004). The project overlooked the socio-technical complexities and conflicts of the water access, from governance and regulation to exclusion questionings (e.g., in case the device detects arsenic, what would be user's accessibility to alternative water solutions, do they knowingly remain drinking polluted water?). The biosensor was also detached from processes and organizations that could lead to its ultimate production, distribution, adoption, and use.

Case 2: Chagas Molecular Diagnostic

In 2011, a public-private consortia developed a Real-Time PCR kit to detect the parasite *Trypanosoma cruzi*, etiologic agent of Chagas disease (Bortz & Thomas, 2019). Considered a symbol of structural poverty, Argentina presents the highest Chagas infection rate worldwide: over 1.5 million people, representing 3.65% of its population. New cases emerge annually by vector transmission and mother-child transmission. In recent decades, while biological R&D efforts in the disease increased, public health actions and institutions (prevention, vector control, epidemiological statistics) were weakened (Zabala, 2010; Ministry of Health, n.d.).

The Sectoral Technology Innovation Fund made a call for competitive grants. Framed under an innovation systems approach, the instrument aimed to foster public-private partnerships for R&D on priority socio-productive issues, overcoming the restrictions of science-push linear technology development (cf. Case 1).

The partnership gathered three relevant actors: (a) the main public R&D laboratory specialized in Chagas molecular diagnostics, (b) the lead diagnostic kit manufacturing company, and (c) a public health institute dependent from the Ministry of Health in charge of the national guidelines and validations for Chagas control. The inclusion of the latter became essential for project development: being inserted within

the Ministry of Health allowed recruiting key actors in several maternity wards in endemic areas to conduct an extensive validation study, quality control and patient follow-up. It also permitted to gather blood samples required to validate a diagnostic kit (Bortz & Thomas, 2019).

The inclusion of the public health institute as a project sponsor blurred the user-producer divide, playing multiple roles: as 'lead user' (von Hippel, 1986), 'intermediate user' (Truffer 2003), as a 'user legitimator' (Schot *et al.*, 2016), but also as a 'user regulator' (fixing national standards) and 'network builder', gatekeeper of a territorially embedded new user network. Maternity ward representatives also became 'intermediate users', with low decision-making level (mainly, clinical data collection and processing) but integrated into the Congenital Chagas Disease Study Group. The focus the local setting where congenital transmission takes place was included, coming to the birth-givers to breach data gaps, build local adequacy and provide follow-up treatment. The patients/mothers (end-users) are 'implicated actors', targeted but absent from the accounts (Casper & Clarke, 1998).

The kit was finally approved in 2020 and became available in 2021. Collaboration between the three parties in user-producer relations (Lundvall, 1988) seems to endure, also with the aligned maternity wards (Benatar *et al.*, 2021) and mutated into a recently approved technology transfer project to be implemented in maternities and public health units (WHO-TDR, 2021).

This case shows a TID trajectory framed under an 'inclusion as a result' approach. Two main technologies are at stake: the diagnostic kit, initially framed as a technology fix for Chagas transmission, and the policy instrument, also implemented as a technology fix. Both initiatives overlooked the social and technical complexities of the structural problems they are inserted into (poverty, endemic Chagas, lack of access to healthcare on one end, the structural decoupling of scholar production and socio-productive needs on the other). In recent years, it shifted its focus towards a more territorially grounded initiative, including intermediate locally grounded users, as key inputs to improve the product, its adoption and implementation.

Case 3: Probiotic School Yoghurt 'Yogurito'

The 'Yogurito Escolar' is a probiotic yoghurt designed to prevent respiratory and gastrointestinal diseases caused by malnourishment by enhancing the immune system. It was developed by a public R&D institute in Tucuman province, the Reference Centre for Lactobacilli (CERELA), with governmental agencies and local producers.

In 2001, a deep socio-economic crisis shook Argentina, driving 50% of the population under poverty, reaching over 60% of households in Tucuman. CERELA

researchers developed a probiotic product for children with unmet nutritional needs. In 2004, they took the idea to a regional multi-actor participatory workshop arranged by the national STI Secretariat, which gathered scientists, local producers, NGOs, and policymakers. In subsequent conversations the idea turned into a first draft for developing a probiotic yoghurt for malnourished children.

By 2006, the CERELA completed the in-lab product set up. Assessing the probiotic effects on children's immune system required conducting a clinical study. This urge to get the product 'out of the laboratory' led to engaging the Ministry of Social Development (MSD) as 'local expert' (Sørensen, 1996) and 'intermediate user' (Truffer, 2003). The implementation in 2007-2008 of a double-blind trial with 298 children in community kitchens in peri-urban Tucuman involved a user-producer interaction (Lundvall, 1988) by an over 150-people team led by CERELA researchers. Local experts were engaged (Sørensen, 1996), from MSD officers, nutritionists, community-kitchen staff, social workers, dairy manufacturers, to physicians. The latter discussed the initiative with parents (intermediate users) and surveyed children's health, monitoring the results of probiotic intake. The trial also allowed surveying children's (end users, user-consumers) social and sanitary living conditions and adjusting the yoghurt to their taste preferences. This joint work initiated a locally embedded social learning process (Lie & Sørensen, 1996).

The clinical trial's results in terms of strengthening children's immune system gained public resonance through regional media coverage. In 2008, the MSD adopted the 'Yogurito' as the central feature of a provincial social policy. They agreed with CERELA to mass produce it and deliver it triweekly to children in public elementary schools. In the same movement, the MSD became Yogurito's co-designer and implementer (mostly, in its organizational strategy), sponsor, and 'user-purchaser'.

While addressing nutritional and health deficiencies, the program designed a local development strategy to recover an impoverished provincial dairy chain. To design and scale up the program, the MSD brought together small/medium local dairy farmers to produce the yoghurt and sell it to MSD, and Education, Health and Productive Development Ministries (intermediate users) to coordinate the implementation of the Probiotic Program. The project required boosting productive infrastructure for a mass production. The distribution started with 56.000 children in 2008, reaching 200,000 in 2010. The implementation required creating the conditions for the project's adequacy by coordinating with other intermediate users, such as teachers and school principals to deliver it at school, and physicians in primary healthcare centres.

These exchanges, built upon the participation and problem-solving interaction developed during the clinical study (2007-2008), led to a multi-actor local

management board as a user-producer space for action coordination (Lundvall, 1988). This allowed designing and adjusting the technology and its policy implementation based on a wide understanding of local expertise (Lie & Sørensen, 1996; Constanza Chock, 2020). This involved negotiation between different actors, expertise and interests to build the project's on-site working: scientists (R&D), MSD (policy praxis and logistics), farmers and manufacturer (dairy production and distribution), Ministry of Productive Development (livestock policies), Health, and Education (educational skills). The latter channelled the voices and conflicts of on-site education and healthcare workers (intermediate users), and even children (users-consumers), adjusting the product to their preferences. These adjustments were based in a continuous monitoring of effective users and their practices, preferences, objections and needs.

The local management board deepened and stabilized interactive social learning. These problem-solving dynamics gradually improved the product, processes, and the organisational scheme (Lundvall, 1988). This allowed locally grounded adequacy, building its working amidst interpretive flexibility (Kline & Pinch, 1996), scaling-up the program, diversifying the probiotic portfolio to reach isolated provincial areas, accumulating new local techno-productive capacities (Lundvall, 1988) and promoting its domestication. In the interaction, participants were shifted from their background expertise(s) and challenged into developing new skills through social learning (Sørensen, 1996; Constanza Chock, 2020).

As a result, the Health and Social Development ministries identified improvements in children's health; the Education ministry emphasized better school attendance and performance. Concurrently, for Tucuman's dairy farmers the program prompted the valorisation of the provincial dairy sector, in crisis since the 1990s due to economic deregulation and land concentration. Since 2006, sectorial actors had self-mobilized to gather atomized farmers and promote recovery activities, leading to the creation of the Dairy Board of Tucuman. In 2008, the beginning of 'Yogurito' required large-scaled coordinated provision milk, encouraging the creation of the Dairy Farmers Association (APROLECHE), which became part of Yogurito's coordination team.

In subsequent years, the farmers' identity was shaped by Yogurito's development (Kline & Pinch, 1996), being reinforced as a collective actor geared by the growing state demand to implement the Probiotic Program. This was not only achieved through their milk provision but under an organizational scheme where they coordinated the production, from raw material to value-added finished product. This capacity building dynamic stimulated the creation of Tucuman's Dairy Technological Hub in 2011 (running to this date), shaping the dairy farmers collective identity and

growing influence in decision-making. This also marked their transformation from milk farmers to Yogurito's co-designers and key users of the Yogurito's public-policy, all at once.

The 'Yogurito' emerged as an 'inclusion as a result' approach: delivering a technology fix to solve (structural) malnutrition problems. Children were initially conceived as abstract 'user-consumers'. The challenges to implement the device 'in the field' gradually turned the project into an 'inclusion as a process' initiative, stirring local development process, social learning and the self-mobilization of neglected groups. This shift was led by the alignment of heterogeneous actors (scientists, ministries, farmers, manufacturers, teachers, children, physicians), local experts (Sørensen, 1996) to build the local adequacy of Yogurito and the social policy. Being a mostly women-led initiative, Yogurito shows strong 'care' inscriptions, shaping its patterns of use and access, such as the focus on children, families, and household dynamics[2] (Akrich, 1992; Oudshoorn *et al.*, 2004; Schwartz Cowan, 1976).

Children and families (user-consumers), and community kitchen staff and teachers (intermediate users) were included in early stages but in a subordinate role. However, design and implementation of Yogurito as a public policy, allowed broadening other user's governance in technology development and a reconfiguration of the user/producer divide, into 'user-producers' (Schot *et al.*, 2016) or even 'co-designers' (Constanza Chock, 2018) (e.g., MDS and dairy farmers). This fluidity favored both artifact and policy to be continuously shaped by their on-site 'users' and local experts, framing problems and experimenting with solutions from early stages. This participation and role fluidness emerged as a practical response to territorially grounded implementation challenges, transforming actors' identities in turn. The continuity of the project since 2003 enabled enduring learning trajectories that lead to further associative projects between the parties involved.

Case 4: Recycling Cooperative 'Recycling Dreams'

The Recycling Dreams Cooperative emerged in 2003 in La Matanza district, the most populated district of peri-urban Buenos Aires, during the 2001 Argentinean crisis reached 40% unemployment rates (INDEC, 2017; Carenzo, 2017). A group of social movement leaders with a metalwork background started to organize the growing population of waste-pickers in the area, recently unemployed males that collected recyclables from street garbage to make a living (*cartoneros*, collectors of cardboard

[2] Sanbonmatsu (2017) and Blaxill and Beelen (2016) show that women are more likely to make bills dealing with women's issues and children and family issues a priority.

material). Gathering as a cooperative allowed them to improve their income through large-volume sale to improve prices (Carenzo, 2014).

The cooperative stimulated the development of socially just waste management, through collaboration between waste-pickers and waste producers. This has materialized in the innovative project 'Recycling garbage, recovering jobs' (2006-2011) in middle-class neighborhoods, encouraging household recyclable sorting.

However, one of the cooperative's most striking features is their ability to design, build and systematize machinery, tools and processes that allowed its economic viability, processing recovered and classified materials to market them as value-added inputs for manufacturing processes. Cooperative work allowed upgrading their activity through material experimentation and developing an indigenous classification technology. This not only allowed improving their skills to manage materials with a preexisting market but also creating new markets for elusive materials, pushing the limits of their capacities (Carenzo, 2017).

This everyday grassroots experimentation by actors without any formal education was detached from scientific categories, tinkering with materials through sensory deployment. Knowledge was socialized collectively, through oral records of the shared work experience. Cooperative leader's background on metalworking and activism imprinted into technology experimentation and development male-gender script (Akrich, 1992; van Oost, 2003), differentiations between man and women roles and organizational leadership (Kline & Pinch, 1996).

Through trial-error prototyping, a second set of technologies were developed, to press, grind, dry and wash plastic and cardboard, reusing objects recovered from the street. Subsequent improved press models allowed reducing the volume of the classified material. This had economic advantages: cutting-down operational costs and better selling terms. But above all granted a sense of 'professionalization', an understanding of waste-picking as 'work' (no longer a last resort precarious occupation), and their self-affirmation as '*cartonero* workers' (Kline & Pinch 1996). These designs contributed to their political struggle for their activity to be recognized not as 'informal work' but as a socio-environmental 'public service' (Constanza Chock, 2020), within a broader effort made since 2003 by the Latin American Network of Waste Pickers (LACRE Network) (Carenzo, 2014).

The cooperative's technological developments, with a strong *cartonero*-identity affordance imprint, gained regional scale through Red LACRE. The cooperative was granted as 'innovators' with a basic waste-picking technology kit (mill, washer, dryer and press). This involved revising the prototypes, systematizing them through drawings and renders in interaction with engineers and industrial

designers, to make them available to other organizations through open licensing (Carenzo & Schmukler, 2017).

This case shows a grassroots trajectory of 'inclusion as a process'. Recycling Dreams became a regional reference in the waste management realm, as expert actors in the sustainable management and treatment of industrial waste (Carenzo & Schmukler, 2017). The organization defies expert/inexpert and user/producer silos with grassroots 'expert' knowledge that promotes collaboration, collective socialization and co-design. Categories such as 'lead users' (von Hippel, 1986), 'inventive users' (Hyysalo *et al.*, 2013), 'user-producers' or 'users-citizens' (Schot *et al.*, 2016) fall short: it tears apart the user/producer binary, being design imbricated in cooperative's everyday practice of undivided design-fabrication-use-adjustment and political struggle. The cooperative resists the idea of being 'users' of exogenous generated technologies, reinforcing their 'making' and developing bottom-up technology as part as a collective action repertoire that politicize technological design as (at first) practices of resistance or (later) self-affirmation (Carenzo & Schmukler, 2017; Constanza-Chock, 2020).

DISCUSSION

A typology of user approaches based on inclusion/exclusion

Literature review and the empirical cases follow a progression in addressing the user(s)-technolog(ies) relationship through an inclusion/exclusion lens that allowed to identify five types. We stylize below which type of users are framed by theory, their analytical contributions and omissions (summarized in Table 2). Underlying these types is an understanding of the problem of user participation, and how these theories abide/encourage their 'ability to influence techno-cognitive decision making' (Bortz & Thomas, 2017).

Type 1: *Universal users-consumers*. The pioneering IS opened the user agenda, with a central concern to create market advantages through user's input, focusing on their needs and skills. Although different user roles are recognized ('lead', 'intermediaries', 'active', etc.), they are ultimately seen as consumers, sustaining the user/producer divide. These approaches configure unidirectional knowledge flows where users mold technology but not the other way around. These approaches suppress conflict, building universal users (in terms of time, place, gender, income) and neutral

technologies. It assumes a user with (economic, symbolic, cognitive) resources and options to experiment and choose between alternatives for technological change[3].

Transitions theory also falls into Type 1, though some works under this framing included niche' micropolitics (Seyfang & Smith, 2007; Smith *et al.*, 2010) and structural views on power in the regime. This approach does include an understanding of economic accumulation trajectories and a problem-solving view towards an environmental concern that other IS precludes.

Type 2: *Diversity of users-consumers.* These are the pioneering socio-historical studies, drawing from a gender critique. Despite their linearity (sustaining the user/producer divide, users persisting as consumers at the end of the innovation process), these studies brought to light the mutual shaping between users and technologies. They identify micro-power dynamics (power asymmetries, gendered division of labor) in specific domains. Even when they did not address broader power configurations, they introduced the focus on user diversities and specificities, users' spatiality (the home, work, medical consultation), and a first understanding of exclusions within user theory. The 'gender' variable remains unidimensional, disentangled from other exclusion forms.

Type 3: *(In)scripted-(de)scripted users*. Drawing from semiotic and gender perspectives, these studies pioneered the co-construction of users and technologies. Here the visions of the designers are inscribed into the artifact's design, shaping users' actions, which can either abide the scripts or resist them. Here 'users' agency starts taking on more fully, beyond the 'consumer' role. Power comes at the forefront as micro level inscriptions and translation. However, it overlooks the dynamics of economic accumulation, a theoretical bias that is transferred to its case studies. Gender is also inscribed into artifacts, usually as a one-dimensional variable, dissociated from other exclusions. This approach recovers the option of 'resistance'. However, 'de-scription' and 'anti-programming' concepts focus on the designer's gaze, who retains the power in a user/producer binary conception. Although the notions of 'inscription' dismiss the neutrality of the technologies, linearity persists, positioning the analysis at the beginning of the process, the rest being a consequence of the 'design'.

Type 4: *Localized adequacy-building users*. Drawing from social constructivist studies, this type tended towards a full understanding of the co-construction and mutual shaping of users and technologies. Gender is progressively incorporated as a driver

[3] Even in the case of transition towards sustainability theory, while those who suffer most from the environmental crisis are the intersectionally excluded population (Hardoy & Pandiella, 2009; Hoffman, 2021), many environmental solutions – from electric cars to house solar panels – are built as 'exclusive'.

to see broader inclusion/exclusion processes (though in a unidimensional way), changing identities and roles. Power is incorporated both in agency (micropolitics) and structure (semiotic power). Users get involved in technology-making as adequacy builders, exploring these adaptations in specific user-sites, but not as producers from early stages of technological development. Thus, the user/producer binary divide persists. These approaches allow deconstructing the uniqueness of the artifacts, through interpretive flexibility and meaning attributions that occur during use. However, the identity of the artifacts remains constant as the material framing, set by the designers, remains stable.

Type 5: *Situated conflict-embedded users*. This last type gathers the contributions by Cultural Studies and Design Justice approaches, acknowledging their diversities. They converge in the co-construction of user and technologies, emphasizing the multidimensionality of inclusion/exclusion processes, local specificities and conflicts. These approaches emphasize the intersectionality of exclusion, converging gender, class, ethnicity, geography, (dis)abilities dimensions, among others. This type tears apart user-technology universality, whereas centering on their specificities (CS) or advocating for their early inclusion in the design (DJ). While CS holds the user/producer divide, from its trans-feminist origins DJ abolishes this binarity as an enduring asymmetric decision-making process. When 'users' or 'affected people' become present in early design phases, they cease to be 'users' and become 'co-designers', in egalitarian processes of technological development.

Cultural studies remain more subjectivist than objectivist and more symbolic than artefactual, seeing disputes in meaning attribution, but not tackling the material basis of affirmations and sanctions. This material base of punishments and rewards is precisely what Design Justice aims to transform, one artifact at a time. At this point, Design Justice remains as a micro, focal approach, whose scalability is given by activism and expanding their network, but how can it 'transition' from its 'niche' to become a counter-hegemonic alternative?

Table 2. Typology of user approaches under an inclusion/exclusion lens

Type	Approaches	Role of users	Knowledge flows	Deterministic residues/	Governance	Inclusion/Exclusion approach
1. Universal users-consumers	Innovation Studies incl. Transition Theories and Inclusive Innovation ('as a result')	Users-consumers. Sustains user/producer divide.	Unidirectional. User → Technology	Universal users Neutral technologies Linearity (users at the end of the process)	Users as inputs to maximize technology adoption and profit. Process is governed by the designers.	Conflict suppression. Assumes users with resources and capacity to choose. Incl. Innovation: non-problematized unidimensional exclusion (income-based).
2. Diversity of users-consumers	Socio-historical S&T + gender studies	Users-consumers. Sustains user/producer divide.	Incipient mutual shaping of users and technologies. Technology → User	Specific users, user diversity. Linearity (users at the end of the process).	Users reveal patterns of (gender-based) exclusion. Process governed by the designers. Users' agency restricted to consumption.	Micropower dynamics. Unidimensional exclusion (gender based).
3. (In)scripted-(de)scripted users	Semiotic approaches + gender studies	Users-consumers. Sustains user/producer divide.	Pioneer the mutual shaping of users and technologies.	'Inscriptions' dismiss technology neutrality. Linearity (users at the end of the process).	Microlevel inscriptions and descriptions. Governance lies in the designer's gaze. User's agency allows abidance/resistance.	Scarce attention to exclusion. Unidimensional exclusion in semiotic gender studies.
4. Localized adequacy-building users	Social constructivist studies	Users as agents of socio-technical change. Sustains user/producer divide, users as adequacy builders.	Co-construction of users and technology.	Deconstruction of artifacts through interpretive flexibility. Linearity (users as adaptors at the end of the process).	Material framing set by the designers. Users adapt and resignify technologies.	Unidimensional exclusion (gender based). Power in mutual shaping of agency (micropolitics) and structure (semiotic power).

5. Situated conflict-embedded users	Cultural Studies Design Justice	CS: Sustains user/producer divide. DJ: abolishes binarity (users as producers)	Co-construction of users and technology.	Situated users and technologies. CS: users as symbolic world-makers. DJ: users as material world-makers.	CS: governance over social learning (full governance in a late stage). DJ: co-design (full governance since an early stage).	Intersectionality in inclusion/exclusion processes. Acknowledgment of local specificities and conflicts.

Source: own elaboration (Bortz & Thomas 2022).

Implications for inclusion/exclusion dynamics

Empirical analysis showed that none of the user theory approaches as a closed package allowed a deeper understanding on user-technology relations in TID: how they work, who benefits, to what extent they brought inclusive outcomes, enhanced participation, or perpetuated asymmetries and inequalities. The empirical analysis required triangulating multiple analytical tools, simultaneously putting in tension preexisting closed categories. From the review and application of these categories for TID analysis, a set of theoretical-methodological considerations emerge:

a) Market economy inscriptions in user theory and practice

Passive 'end-of-pipe' user-consumers, dissociated from the production, result from the co-construction between economic theory and the capitalist socio-productive model. In historical terms, the user/producer divide began with the trades and consolidated with capitalism and market economy. Since the '1970s, IS's concern on users emerged from the need to build competitive advantages in firms (Schumpeter, 2017 [1934]; von Hippel, 1976). The origins of user theories fall on the producer's side: i.e., the user as an input, resourcing to their knowledge and needs to inform design-production-commercialization processes to maximize profit.

'Inclusive innovation' initiatives focused on accessible goods or technology fixes for lower-income sectors ('inclusion as a result' framing), participates in this vision. Observing their 'inclusive' outcomes, distributive effects (in terms of knowledge, extended governance, use, transformation of innovation trajectories, etc.) remain unchanged: in structural poverty situations it is hard to affirm that gaining access to one specific good (a cell phone, a solar panel, a home appliance) implies an 'inclusive' gain for the intended user-consumers. However, there is a greater pattern of accumulation by the companies that supply goods for the 'bottom of the pyramid' (Prahalad, 2010; Kaplinsky, 2011).

The cases showed the limitations of these inscriptions in TID design. In Case 1 (arsenic biosensor), the product was not manufactured nor used by their intended, undefined and abstractly built users. Case 2 (Chagas kit) included users-intermediaries and users-legitimators in technology design, improving the kit and its field implementation. However, local 'brokers' were involved in a subordinate role (as informants, data collectors and processors). This intervention persists as a technology-fix facing intersectional and structural inequality (gender, poverty, geographic, ethnic). Yet, the excluded populations (women, in childbirth/puerperium situation, with scarce access to health services), remained absent and these broader inequalities remain unaddressed.

b) Determinist inscriptions in user theory and practice

In the user/producer demarcation, the inscriptions of the determinist science-push innovation model persist: linearity, including users at the end of the process, the neutrality of the artifacts, and their universality. The theoretical review showed the persistence of neutrality in Types 1-2 (overthrown by semiotic studies), of universality in Types 1-3 (deposed by constructivist and Type 5 approaches) and linearity in Types 1 to 4 (with end-of-pipe users).

Cases 1 and 2 showed the inadequacy of linear, neutralist and universalist premises for TID design, as they end up not being manufactured or adopted, perpetuating exclusion patterns. Case 3 (Yogurito) showed a transition of a TID project, from a deterministic conception (linear, neutral, universalist) towards non-linear models of design and implementation, including broad users and local expertise. As users increase their influence in decision-making, becoming 'co-designers', user/producer dichotomies are dissolved. Case 4 (Recycling Dreams) overthrew linear assumptions, building iterative, highly contextualized, and political technological development processes.

c) Binary endurance

Types 1 to 5 show the cognitive exploration of the B-sides of capitalist production, its material and symbolic consequences and interconnected exclusions, and 40 years of new concepts to address them. The literature showed the persistence of the user/producer dichotomy, a linear residue that persists as an external and pre-given categories derived from a 'residual realism' (Chilvers & Kearnes, 2020), difficult to fit into TID empirical trajectories. As the cases moved away from linear market-oriented innovation dynamics towards collaborative/co-design dynamics, with more 'fluid' user identities (Cases 1 to 4), these fixed categories became inadequate. In other words, in the transition from 'inclusion as a result' to 'inclusion as process' cases, the user/producer artificial divide –and its derived analytical categories- became diluted. TID analysis challenges this 'modern' dichotomy and demands new 'non-modern' analytical tools (Latour 1991), to capture multiple, diverse, and changing identities, which are 'users', 'producers', 'activists', 'citizen builders' – and many more – all at once.

d) Review of 'experts' categories

The progressive questioning of the user/producer divide in Cases 1 to 4 and Types 1 to 5, also enquires on the notion of 'expert' in standard linear terms (scientists, technicians, designers, people with higher education). Cases 3 and 4 and Types 4 and 5 showed the importance of including actors with diverse sources of expertise and knowledge negotiation skills. Case 4 (Recycling Dreams) and Type 5 (especially DJ), show how these knowledge negotiations occur in asymmetric power situations, reinforced by pre-existing material bases that distribute rewards and punishments.

In these negotiations, governance over problem-solving is at stake. While in Types 1 to 3 users are absent from problem-solving dynamics, in Type 4 they come in later stages (framing new concerns over use, adapting existing technologies), in Type 5 DJ users/affected actors are key. In Cases 1 and 2, user-beneficiaries were absent; in Case 3 they were progressively included (children in a subordinate way, the MDS and the farmers as co-designers). In Case 4, the expertise was co-built with the needs of its 'users' and their productive capacities.

Returning to our initial definition of participation, this endowment assigns asymmetric capacities to influence techno-cognitive decision-making, which requires the deployment of counter-hegemonic actions by excluded groups (from resistance to creating new models for the design-production-distribution of goods and services, as shown in Cases 3 and 4).

e) Artefact centrality

User theory (Types 1 to 5) focused mostly on products, disregarding services (maybe the Internet is the exception), processes or organizational technologies. Literature review conducted under the light of TID cases shows the need to open user analysis not only to products (consumer goods), but also to production machinery, processes and systems, public services, organization technologies and even public policies. In Case 3 these were critical issues to build the situated working of the Yogurito and the socio-productive policies that sustained it. Case 4 showed that 'inclusion as a process' initiatives, through territorially embedded social learning, which allow to transform identities and reverse socio-economic power asymmetries, requires a more detailed account on machinery, productive processes and systems.

f) One-dimensional exclusion/inclusion

Type 1-user theories do not account for any exclusion form. This bias extends to 'inclusive innovation' initiatives derived from this type, framing exclusion by reifying

poverty on a unidimensional income basis (Kaplinsky, 2011; Foster & Heeks, 2013; Chataway *et al*., 2014). This minimizes/neglects conflict and sustains the *status quo*. It expects to achieve the 'inclusion' of end-users through access to goods by the same system and rules that excluded them in the first place while, simultaneously, benefiting accumulation dynamics in firms.

Types 2 to 4 showed exclusions in a one-dimensional manner, either by gender (Schwartz Cowan, 1976; van Oost, 2003; Oudshoorn *et al*., 2004) or by access ('have-nots', Wyatt, 2003). However, TID Cases 1 to 4 show the structural intersection of exclusion dynamics, not only in income/access to goods, but also to life-enabling services, cognitive asymmetries, gender, ethnic-racial and geographic factors. While Type 5 includes an intersectional approach to exclusion dynamics (and consequent inclusion challenges), its counter-hegemonic action remains oriented towards including users one artifact at a time, not addressing the socio-technical ensemble as a whole, towards a systemic transformation.

More broadly, Types 2 to 5, show a progression on the exclusion critique (e.g., reporting passivized or victimized users, biased 'universal' users/technologies, exclusions and resistances). This allows reviewing the accumulation of power. It is not only about the exclusion/non-participation of 'the poor' or 'women and diversities', but about also the condition of passive consumer/alienated user of the middle sectors. Therefore, the user agenda 'for inclusion' is not only a problem of the 'excluded' or 'developing countries'; it becomes a questioning on our 'socio-technical citizenships' as a whole.

At this point, while Type 1 approaches tend towards a *status quo*, the progression to Type 5 leans to counter-hegemonic proposals. Their scaling-up may change the forms of design-production-use. The critical review of Types 1 to 5 and of Cases 1 to 4, account for these overlapping exclusions and conflict arenas as well as incremental processes of expansion of socio-technical rights and participation in decision-making.

CONCLUSION

This work and its literature review was motivated by the theoretical constraints we faced while analyzing user(s)-producer(s)-technologie(s) relations in TID cases (Thomas & Bortz, 2017; 2019; Thomas *et al.*, 2017). As users/producers of theory we explored the 'inscriptions' (Akrich, 1992) in user theories as analytical devices through an inclusion/exclusion lens. We aimed to understand the relation between approaches to user involvement, inclusion framings (as a result or as a process), and

their 'inclusive' outcomes (as access to specific consumption, or as broadening rights, governance and more equitable distribution of the benefits of innovation).

This allowed stylizing five user theory types, ranging from passivized users – as inputs to the innovation process-, identifying neglects and recovering user's agency, from its symbolic attribution to the co-design of the material bases that shape their living. As we approach these last types, user/producer dichotomies derived from 'modern' (Latour, 1991) deterministic and market-oriented residues becomes diluted. This expands the understanding of expertise, emphasizing knowledge negotiation and social learning. In reflexive turn, the mutual nurturing between TID literature and case studies, user theories and intersectional gender studies that lead to the five user theory types also helped broadening our original dichotomous distinction of inclusion framings (as a result/as a process), towards an augmented, multidimensional understanding of user inclusion/exclusion. There is a need to advance further on analytical perspectives that may capture new multi-stakeholder, multi-role, pluri-cognitive units of analysis.

User theory showed a profuse development both in the understanding of 'users as inputs' (Type 1) and in the criticism of successive exclusions and subordinate counter-hegemonic actions (Type 2 to 5). However, this leads to only partial or isolated solutions facing a structural problem: critical works that address privileged consumers and hegemony building through production and use are scarce. Todays' great global challenges (from the climate crisis, ecosystem degradation to the COVID-19 pandemic) show the need for a complete and systemic transformation of design-production-use circuits. The theoretical overcoming of 'modern' dichotomies, also in this matter, is crucial to improve our socio-technical rights, getting involved in the material bases of affirmations and sanctions that shape our viable/non-viable livelihoods and sustainable/non-sustainable development paths.

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