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Multidimensional analysis of DID sustainability in the physical-virtual context

Análisis multidimensional de la sostenibilidad-DID en el contexto físico-virtual

Análise multidimensional da sustentabilidade-DID no contexto físico-virtual

Gonzalo Andrés, Universidad Nacional de Entre Ríos, Paraná, Argentina (gonzalo.andres@uner.edu.ar)

Patricia San Martín, Universidad Nacional de Rosario, Rosario, Argentina (sanmartin@irice-conicet.gov.ar)

Guillermo Rodríguez, Universidad Nacional de Rosario, Rosario, Argentina (guille@fceia.unr.edu.ar)

ABSTRACT | The aim of this article is to rethink the approaches and methodologies to investigate the emerging processes of communication in the current physical-virtual context. To this end, it posits the need to develop an integral view that includes the practices of production and use of technologies along with the creation of contents and the materiality of expressive languages. In this vein, it proposes a multidimensional analysis model to evaluate the sustainability processes of dynamic intermedial devices (DID) developed in different socio-institutional frameworks dedicated to communication, education, and cultural management. This model is made up by four interrelated dimensions: politicalinstitutional, technological, social, and intermedial. Each dimension interacts with the other and is interwoven with empirical phenomena. We consider that this model constitutes a theoretical-methodological contribution to communication and technology studies, since it has methodological flexibility to adapt to different case studies, allows the integration of different research methods and techniques, and enables a characterization that articulates macro and micro social processes in the same approach. Finally, from a constructivist perspective, it is argued that in order to study the socio-technical sustainability of these devices it is necessary to understand technologies as artefacts and systems that developed, model and resignify themselves in different ways in each context.

KEYWORDS: methodology; communication; technology; interdisciplinary; sustainability.

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RESUMEN | *Este artículo aborda el desafío de repensar los enfoques y las metodologías para investigar los procesos emergentes de la comunicación en el actual contexto físico-virtual. Para ello, postula como necesario desarrollar una mirada integral que incluya a las prácticas de producción y utilización de tecnologías junto con la creación de contenidos y la materialidad de los lenguajes expresivos. En esa dirección, propone un modelo de análisis multidimensional para evaluar los procesos de sostenibilidad de dispositivos intermediales dinámicos (DID) desarrollados en diversos marcos socio-institucionales dedicados a la comunicación, la educación y la gestión cultural. Dicho modelo está conformado por cuatro dimensiones interrelacionadas: políticoinstitucional, tecnológica, social e intermedial. Cada dimensión interactúa con la otra y se entrama con los fenómenos empíricos. Se considera que este modelo constituye un aporte teórico-metodológico para los estudios de comunicación y tecnología, pues posee flexibilidad metodológica para adecuarse a distintos casos de estudio, permite integrar diferentes métodos y técnicas de investigación y habilita una caracterización que articula procesos macro y micro sociales en un mismo abordaje. Finalmente, desde una perspectiva constructivista, se argumenta que para estudiar la sostenibilidad socio-técnica de estos dispositivos es preciso entender a las tecnologías como artefactos y sistemas que se desarrollan, modelan y resignifican de distintas maneras en cada contexto.*

PALABRAS CLAVE: *metodología; comunicación; tecnología; interdisciplina; sostenibilidad.*

RESUMO | Este artigo aborda o desafio de repensar abordagens e metodologias para pesquisar processos de comunicação emergentes no atual contexto físico-virtual. Para isso, postula que é necessário desenvolver uma visão integral que inclua as práticas de produção e uso de tecnologias, juntamente com a criação de conteúdo e a materialidade das linguagens expressivas. Nesta direção, propõe um modelo de análise multidimensional para estudar os processos de sustentabilidade dos "Dispositivos Intermediáles Dinâmicos" (DID) desenvolvidos em várias instituições dedicadas à comunicação, educação e gestão cultural. Cada dimensão interage com a outra e está entrelaçada com os fenômenos empíricos. Este modelo é uma contribuição teórico-metodológica aos estudos de comunicação e tecnologia, porque tem flexibilidade metodológica para se adaptar a diferentes estudos de caso, permite a integração de diferentes métodos e técnicas de pesquisa e permite uma caracterização que articula macro e micro processos sociais na mesmo abordagem. Finalmente, a partir de uma perspectiva construtivista, é argumenta que para estudar a sustentabilidade sócio-técnica desses dispositivos, é necessário entender as tecnologias como artefatos e sistemas que se desenvolvem, moldam e se resinificam de maneiras diferentes em cada contexto.

PALAVRAS-CHAVE: Metodologia; Comunicação; Tecnologia; Interdisciplinaridade; Sustentabilidade.

INTRODUCTION

The expansion of the information paradigm made it possible for communication studies to focus on research into social phenomena that were not necessarily related to the mass media. This is because the increasing process of mediatization meant that the logic of the media influenced other social institutions. That is, communication technologies as institutions are related to other institutions and generate mixtures in the logic of each of these institutions (Krotz, 2017), so that these technologies influence the functioning of private, public and state organizations. Contemporary societies are thus mediatized not only because the media and communication technologies play a central role in discursive production and circulation, but also because practices and institutions are increasingly structured around communication artifacts and languages (Manovich, 2020).

Given this panorama, studies on virtual environments and digital technologies have helped to refute the online/offline dichotomy and adapt quantitative and qualitative research techniques and tools to these scenarios (Rodríguez Cano, 2022). This has forced communication research to develop theoretical frameworks and methodological strategies to study the processes of integration of technologies in different domains and social sectors (Sierra Caballero & Alberich Pascual, 2019). In this sense, this article proposes a multidimensional model of analysis that participates both in the process of co-construction of a dynamic intermedial device (hereafter DID) and in the evaluation of its sustainability in different socio-institutional or organizational frameworks.

DID refers to socio-technical-cultural networks with specific purposes that integrate heterogeneous technologies into the current physical-virtual context. These networks promote non-exclusive pluralistic interactivity processes associated with the creative appropriation of technologies and are usually co-constructed on the basis of strategic inter-institutional/organizational alliances linking educational, academic, cultural or community spheres. Within this framework, a DID is considered to achieve the conditions for sustainability if there is evidence of social validation and durability over time, showing that the strategic alliance is deployed by multiple agencies and succeeds in making the agreed creative appropriation purposes effective.

LITERATURE REVIEW

In the analysis of communication technologies, approaches have prevailed that focus on aspects such as the daily use of technologies, the creation of content in social networks or the integration of technologies in institutions. In this context, Boczkowski and Siles (2014) conducted a review of the specialist

literature in which they highlight the predominance of two approaches. The first looks at production or consumption, i.e. the processes involved in the creation of technologies or the way they are integrated into people's daily lives or into different institutions. The second examines the content produced or its material dimensions, i.e. it understands technologies as languages for generating meanings or as cultural artifacts.

In this way, the authors have delineated four quadrants that organize research in this area: production/content, consumption/content, production/materiality and consumption/materiality. These themes made it possible to generate knowledge about how artifacts or technical systems are configured, how they are used in different contexts and in different social groups, how meaning is produced by each of them, and how they contribute to the social circulation of information and meaning. However, these divisions also led to limitations in subsequent studies, as the assessment of the life cycles of technologies was restricted to disciplinary boundaries. For example, social or cultural studies of technology focused on the creation and use of artifacts or technical systems, while communication studies, semiotics, and anthropology focused on media discourses, audience behavior, and the political economy of the media ecosystem.

Boczkowski and Siles (2014) therefore argue for research on communication technologies that develops a cosmopolitan perspective and incorporates different empirical objects and different methods for its approach. The aim would therefore not be to add techniques within a study, but to form a theoretical framework that integrates the interdisciplinary relationships between various factors. In this sense, it is possible to highlight research that has configured multidimensional models to investigate different mediatized social practices or the functioning of different platforms. For example, Carpentier (2012) has proposed a model of access, interaction and participation to analyze citizen participation in the media ecosystem. In his view, participation in virtual environments implies much more than just access or interaction, as it takes into account the involvement of subjects in decision-making. This type of process can be expressed through (i) the production of content and (ii) participation in the creation and management of media organizations or technology producers.

Following Carpentier (2012), access, interactivity and participation in the processes of discursive and technological production and recognition are expressed in different ways and can therefore be examined through four categories: technologies, subjects, contents and organizations. The relevance of this proposal was that the analysis of each category implies the recourse to different research techniques and, moreover, adopts a maximalist perspective of

participation that allows the study in different contexts with different forms of mediatization. However, the proposal is limited to classical concepts of sociology and political science, without taking into account the characteristics of artifacts and technical systems.

Sandoval (2018) outlined a model to study the processes of technological appropriation, particularly in the context of the development of mobile telephony in Argentina. Four modes are considered: technological development, sector policies and regulations, business strategies and, finally, meanings, resignification and use by users. As you can see, the characterization of the process includes aspects of different nature. Thus, in addition to the artefactual arrangements, a communicative approach is also more strongly emphasized.

The analysis model by Sánchez-Caballé and colleagues (2021) is another of the proposed models and revolves around the digital competences of teachers and students in higher education institutions. For this purpose, it includes four dimensions of competence: information, technological, multimedia and communicative competence. For each of these dimensions, there are corresponding indicators related to the evaluation and organization of information, the use of hardware and software, the processing of data in different formats, the understanding and creation of multimedia content and participation in digital citizenship. These authors highlight the advantage that the model can be adapted to analyze different educational settings and to design training activities for the development and acquisition of digital skills at the university.

Another relevant methodological approach is that of Van Dijck (2016) for the study of digital social networks. It pays holistic attention to the design of the technology, user activities and the content produced, as well as the ownership, governance and business models of the platforms. To this end, it integrates contributions from actor-network theory - to show the co-evolution of networks of people and technologies - and from political economy to examine the economic infrastructure and the political and legal regime. This proposal represents an important theoretical innovation in the field, as communication and technology studies generally do not address technology production as an object of study, nor do they incorporate theories from science, technology and society studies (Siles et al., 2019). The so-called social studies of technology have shown that technological change is a multidimensional phenomenon that includes cognitive, organizational, economic, ideological and cultural factors (Tabares Quiroz & Correa Vélez, 2014).

As far as studies on intermediality are concerned, there are a variety of conceptualizations of the different existing supports and languages of expression. However, the classification by Wolf (2011) stands out:

1. Extra-compositional intermediality refers to the relationships between media and categorizes them as transmediality, intermedial transposition and remediation. Transmedia narratives, for example, use multiple media platforms (such as comics, novels, video games, mobile device applications, films, etc.) to tell a transversal story (Scolari, 2020; Rost et al., 2016). These narratives are characterized by the fact that a) each medium functions as a stand-alone experience but is connected to the others to contribute to a larger narrative, and b) the narrative is participatory, as the audience actively develops the story by moving through the media and thus understanding it as a whole. Similarly, intermedia realization is the transformation and adaptation of a work to other media. This is relevant to the multimodal production seen in recent approaches to web accessibility (Cenacchi et al., 2021). Remixing is the process by which media merge or change to create new media. A current example is the networked interactive video game, in which traces of several media and intertextualities can be recognized.

2. Intracompositional intermediality encompasses the relationships that take place within a single work, such as plurimediality and intermedial reference. Plurimediality refers to a single narrative work (e.g. theater, opera, performance art) that is integrated through the combination of multiple elements and media. Intermediality, on the other hand, is the allusion to another work, genre or medium.

Thus, it could be said that some types of intermediality have a long historical development, in which the communication technology involved and the resulting language of expression explain the long path of mediatization (from drawings carved in stone to writing, from the printing press to e-mail, from virtual environments to artificial intelligence). This makes it possible to reflect on how the hypermedial (a term that alluded to hypertextual and multimedia compositions at the end of the 20th century) coexists today with the compositional and creative possibilities of traditional expressive languages and 4.0 technologies (augmented reality, 3D simulation, artificial intelligence, etc.).

This theoretical background underlies the methodological choices made in the development of the multidimensional analysis model of sustainability DID presented in this paper. Concepts from various disciplines were integrated in

favor of a comprehensive view of the sociocultural processes of the production and use of technologies and content.

CHARACTERIZATION OF A DID

The presented analysis model has its background in a line of research, development and innovation developed for more than 15 years, first called Dynamic Hypermedial Device (DHD) and now Dynamic Intermedial Device (DID).

In general, the theoretical perspective is based on the constructivist approach to technology (Thomas et al., 2019) and on the mediatization theory of communication processes (Verón, 2015). The methodological strategy is developed in an interdisciplinary work based on a complex and multidimensional view of social processes (García, 2007), aiming to develop several methodologies that can be adapted to the phenomena to be studied or the technical artifacts to be developed (Jensen, 2014)[1] .

The keys that form the analytical framework for sustainability DID are:

- Supporting networks: The term DID refers to socio-technical-cultural networks that enable plural and non-exclusive interactivity processes from a heterogeneous spatial and technological diversity, conceptualized as DID interactivity. The peculiarity is that they are co-constructed as a network with an explicit purpose related to the educational, academic, cultural or community domain. Based on a socio-technical approach (Thomas et al., 2019), the network's capacity to act is key to creating and strengthening strategic alliances that make it possible to achieve the proposed objectives.
- The non-exclusive: DHD explicitly adheres to the guidelines and regulations for free software, open access to information and knowledge, web accessibility, open education and open science, and the promotion of multimodal content production with a variety of carriers and formats. The impact of the dynamics of the network is taken into account in the Accessibility DHD (Cenacchi et al., 2021), especially in the criterion of flexibility, which is supported by

1. Based on the theoretical-methodological framework of DHD/DID and other contributions, the multidimensional analytical model of sustainability intangible cultural heritage - social inclusion was proposed using seven examples from Latin American and Caribbean countries (San Martín, 2022).

the notion of co-responsibility of members/participants in the production of objects and in the communicative aspect.

- Articulation between textual and technological configurations: from a semiotic point of view, it can be said that both a DHD and a DID are mediatized means of communication that enable the deployment of different social practices that take effect through the emergence of communication phenomena oriented towards different purposes, always involving the articulation between textual and technological configurations.
- Active engagement in co-construction: with a view to the sustainability of these institutions, without ignoring the constitutive tensions of any socio-institutional or organizational framework, the members of the network assume a responsible and distributed participation in order to achieve the agreed objective. This commitment refers to an ethical aspect that is existentially constituted as an authentic, esthetic and political physical-virtual dwelling (San Martín et al., 2022). If this is proven, it can be argued that a DID presence has been co-constructed.

THE IDD-SUSTAINABILITY MODEL

The proposed model is the result of the theoretical and empirical study of the problem, the post-factual study of completed projects and the experimental and reflexive intervention in successive R+D+i projects where the production and appropriation of technologies has been analyzed. Among the cases studied, it is worth mentioning the collaborative creation of the plural memory of a city in Santa Fe (San Martín et al., 2014), the construction of a collaborative work tool in a research institute (San Martín et al, 2017), the implementation of a virtual campus in a university institution (Andrés & San Martín, 2019), the development of cultural heritage awareness projects (San Martín et al., 2019) and the mandatory virtualization carried out in a Faculty of Education during the COVID-19 pandemic (Andrés & San Martín, 2022a, 2022b).

These studies took into account different factors: available artifacts, regulations, organizational dynamics, pedagogical strategies or the dissemination and preservation of information and knowledge/products created and shared, to name a few. The analyzes have shown that different practices of technological use and appropriation are carried out to the extent that certain artifacts or technical systems meet the needs, concerns or demands of the social groups involved.

The analytical model of sustainability DID is oriented towards case studies at the meso-social level, as this is where macro-general processes (national legislation,

large-scale technology production, etc.) materialize and are articulated with the diversity of micro-social practices of technology use in situated contexts. That is, it assesses how processes of management, production or creative appropriation of technologies are carried out in educational institutions, universities, media (analog, digital or convergent) or cultural projects.

This model consists of four interconnected dimensions: political-institutional, technological, social and intermedial. These dimensions are complementary and have no hierarchical relationship or order.

Following the successive research projects and case studies, the components (variables and indicators) of the model were defined. Each of the variables consists of empirical indicators that refer to characteristics of different types and contribute to the multidimensional analysis of the sustainability of DID. Likewise, each indicator can have an index that establishes qualitative gradients or quantitative scores for its weighting, or can be used in sub-indicators if necessary.

To enable a complex and contextualized approach to the problem, each analytical dimension interacts with the others and is interwoven with the empirical phenomena. Below is a general description of each dimension and the variables and indicators of different types that make up each of them and that may be applicable or appropriate to different case studies.

Political-institutional dimension

Every institution is the result of persistently repeated practices in a space-time that gradually acquired structural principles and became normative (Giddens, 2015). As a rule, technological integration processes are driven by organizations or institutions of different orders, be it in production, education, science, journalism or at government level. The analysis of the socio-institutional framework is of fundamental importance, as they are the spheres that enable and at the same time limit the actions of the actors. These institutions act as a regulatory framework for practices. This was evident, for example, in the digital transition of *The New York Times* and the associated development of specific skills among its journalists (Nafría, 2017) or in the diverse strategies implemented by various educational institutions to promote digital skills among teachers (Castañeda et al., 2018).

Thus, socio-institutional frameworks constitute practical environments (Quinchoa-Cajas, 2020) in which meanings about technological innovations are constructed and the practices of use (or non-use) of the technologies employed are materialized. It is in these socialization spaces that macropolitics and general programs related to technological infrastructure take shape.

Institutional policies, norms and regulations are thus those that promote or hinder the practices and mechanisms necessary for socio-technological change and innovation. Through rules (written or not) and communication measures (formal and informal), consensus and legitimacy of the technological integration process are promoted (Sánchez-Caballé et al., 2021). They are also the ones who provide the specialized personnel and equipment necessary to create the conditions for the sustainability of socio-technological changes.

However, coercion or compulsion does not guarantee the social validation or durability of a technological or communicative change. This was evident, for example, in the educational institutions that carried out a forced virtualization of their teaching and learning practices during the physical isolation caused by the COVID-19 pandemic, but then returned to face-to-face practices with a low level of creative appropriation of technologies in the classroom. Therefore, it is important to analyze whether organizational changes or technological integration processes take into account the needs of the groups involved. For example, it is important to examine what happened in the cases of staff training and guidance, as this highlights the possible asymmetries between institutional projects and the concerns of the actors involved.

Variables	Indicators
Organizational strategies	- Existence of organizational projects to integrate technologies. - Implementation of institutional policies. - Institutional regulations. - Ad hoc provisions and regulations (type, level, quantity, quality, facilitating or not,...).
Technical staff	- Provision of specialized maintenance and management personnel (stable, temporary, contracted, sufficient, insufficient, level of training,...).
Financial resources	- Financial allocations for the budget (sufficient, insufficient, own, external, planned in the budget, updated at the inflationary rate, covers all items,...)
Organizational restructuring	- Articulation of procedures and actions of different areas. - Tensions, resistances and emergent dynamics (high, medium, low,...).
Logics and practices instituted	- Habits of use (and non-use) of technologies in the organization (daily, sporadic, contextualized, consensual or not, ...). - Meanings and perceptions about integrated technologies. (positive, negative, neutral, adequate, inadequate, accessible, distracting,...).

Table 1. Variables and indicators of the political-institutional dimension

Source: Own elaboration.

Technological dimension

The expansion of the information paradigm has gradually changed productive practices, intersubjective relations, the production and circulation of information and knowledge, the forms of teaching and learning, and the times and boundaries of organizations. In fact, the media and communication system is one of the areas that has undergone the most changes, "(...) because innovation in newsrooms, both traditional media and digital natives, has changed the profile and working techniques, which are now permeated by digital tools" (López-García et al., 2017, p. 87).

It is evident that the availability and accessibility of artifacts and technical systems are necessary conditions for the progressive development of technological skills (Van Dijk, 2017). This dimension takes into account the technical infrastructure available in the socio-institutional frameworks examined: Hardware and software equipment, connectivity, high-speed networks, processing capacity and storage of data volumes. This in turn requires economic, human and logistical resources for their maintenance, renewal and constant updating.

Technological integration in work, educational, artistic or journalistic activities is difficult if the organization does not have available hardware, robust software with connectivity, adequate network architecture and even robotics artifacts and artificial intelligence developments. It is increasingly necessary to have latest generation and high performance technological equipment that allows the use of creative and innovative intermediary co-constructions (material artifacts) with operational application horizons in different areas, located in spaces called makerspaces, fablabs, citizen labs and others, and that those who develop or have their own programs or environments have an intuitive and accessible interface. The design of user interfaces is key to the development of mediatized practices, which implies that they are studied in terms of usability and accessibility for the people who use them. In this sense, it is important that technological designs take into account the international standards set by the *Web Accessibility Initiative* (https://www.w3.org/WAI).

Variables	Indicators
Hardware available	- Quantity, quality and type of technologies available. - Robustness of network infrastructure and connectivity (high, medium, low). - Size of available servers (sufficient, insufficient, potentially scalable,...). - Stability of servers and virtual environments (continuous, discontinuous,...).
Software selected	- Choice and adoption of virtual environments or platforms. - Interoperability of platforms, systems and networks. - Adoption of free or corporate software. - Security and privacy of the organization's information. - Availability of web hosting and database services (maintainable, adequate, scalable, robust, interoperable,...).
Design of interfaces	- Usability of virtual environments and platforms (high, medium, low). - Types of visualization and information search. - Virtual environment design, modeling and testing (according to international and national standards,...).
Accessibility of interfaces	- Implementation of design actions and testing of web accessibility standards (access to testing methodologies and tools, description of barriers, configuration of alternatives,...).
Equipment technology	- Versatility, variety and quantity of physical tools, measuring equipment and state-of-the-art machinery.
Services maintenance	- Dedicated technical support staff. - Human resources dedicated to hardware and software design, management and optimization. - Amount of economic and logistical resources for optimization, management and acquisition of hardware and software (sufficient, insufficient, adequate,...).

Table 2. Variables and indicators of the technological dimension

Source: Own elaboration.

Social dimension

The functioning of a technology involves "the action and outcome of an interactive relationship between humans and non-humans, between actors and artifacts connected as part of a socio-technical alliance" (Thomas et al., 2019, p. 151). Therefore, the development of DID in a socio-institutional framework or a cultural or communicative project is only sustainable if it is linked to a network of subjects, artifacts, knowledge, habits and norms.

The way in which people internalize technical objects in their life practices is conditioned by the socio-cultural configuration to which they belong. The production of mediatized practices implies a creative and inventive activity linked to the available technical infrastructure. There are no linear or clear socio-technical trajectories; rather, each process of change or technological innovation

is configured according to the forms of use, local characteristics and specific resistances (Sierra Caballero & Gravante, 2016; García Canclini, 2019).

Any practice of technology use in a DID involves a creative act in which a person enters into a relationship with technological objects in order to appropriate, modify and redesign them. These instrumental and cognitive skills are developed in an intersubjective relationship with others. As explained in the previous section, participation in a DID must have a provisionality that redefines the processes of responsible and non-exclusive interactivity. Indeed, the construction of a socio-technical-cultural alliance that guarantees the sustainability of a DID is characterized by tensions, refusals and consensus on the forms of use and non-use.

Therefore, this dimension examines the instances of assimilation, adaptation, technological inclusion and innovation in the daily practices of the social groups involved. In particular, the digital skills, the actions carried out, the perceptions about technologies and the creative interventions of the groups involved are taken into account. In this framework, the actions and perceptions of those who express opposition or are not involved in the process of integrating socio-technological change must also be included. This is a key aspect, as social studies on technology have shown the theoretical and methodological relevance of including those people who do not use a technology in order to understand its workings (Tabares Quiroz & Correa Vélez, 2014).

Variables	Indicators
Sociocultural configuration of social groups involved	- Types of requirements, needs and interests of the parties involved.
Perceptions about technologies	- Meanings about technologies and their forms of use.
Digital skills	- Technology use habits among social groups. - Technology usability and accessibility issues. - Learning and training instances on the use of technologies.
Forms of interaction/ participation	- Types of technology use. - Frequency of use of technologies. - Forms of individual and collective use of technologies.
Technology production processes	- Practices of design, implementation and testing of artifacts or technical systems. - Hybrid artifact construction projects.

Table 3. Variables and indicators of the social dimension

Source: Own elaboration.

Intermedial dimension

A technology as a socio-technical construct is not an element that is external to people, but is internalized in their cognitive, expressive and reflexive processes. The confluence of languages and carriers in one and the same device or in a network of artifacts enables new ways of conceptualizing and performing symbolic production.

The notion of intermediality opens up a range of analytical possibilities that better correspond to the multiple ways in which the informational paradigm structures and models technical and symbolic materiality today. From this transversal point of view, it is possible to link the practices of physical presence - with analog support - to the dynamics and spaces of virtuality (websites, social networks and resources available on the Internet) and 4.0 technologies.

In this dimension, we examine, on the one hand, the content and co-construction between disciplinary and non-academic knowledge and their conditions of production, distribution and access and, on the other hand, the creation of artifacts - tangible, intangible and hybrid - and the methodology used to do so. The analysis of these elements is key to assessing whether a technological integration or innovation has been accompanied by a creative appropriation and has contributed to new expressive and productive forms in the dynamics of the organizations involved.

Variables	Indicators
Content production, circulation and accessibility	- Types of content produced and shared. - Content intelligibility and accessibility.
Production of artifacts and technical systems	- Design, testing and implementation of artifacts and systems. - Quality of construction and manufacturing of technological objects.
Skills developed	- Integrating activities and knowledge involved in the design and creation of contents and artifacts. - Work methodologies and productive routines. - Interdisciplinary knowledge and articulation of interdisciplinary knowledge.

Table 4. Intermedial dimension variables and indicators

Source: Own elaboration.

DISCUSSION

The multidimensional analysis model of sustainability DID is the result of the development of a common interdisciplinary theoretical framework that integrates approaches mainly from the sociology of technology, software studies, educational technology, platform studies, digital journalism research and makerspace methodologies.

This model is considered a theoretical-methodological contribution to communication and technology studies for several reasons. First, because it has the methodological flexibility to adapt to different study cases, so that variables and indicators can be changed and adapted according to the context and object of analysis. A multidimensional and complex approach requires that indicators, possible sub-indicators, descriptors and indices are defined on a case-by-case basis. In other words, they should be defined, added or reformulated taking into account the research objectives as well as the spatial and temporal location and the socio-technical quality of the unit of analysis.

Currently, the DID sustainability model is being used to analyze the progress of an interdisciplinary project accredited by a state university entitled *Hacia la no exclusión educativa: la apropiación creativa de tecnología en adolescentes y jóvenes en situación de vulnerabilidad social como articuladora de contenidos curriculare* (Towards non-exclusion in education: the creative appropriation of technology in adolescents and young people in situations of social vulnerability as an articulator of curricular content) (July 2021-June 2024). Synthetically, the case is located in a juvenile detention center (formal and non-formal education in detention, 40 inmates between 16 and 18 years old), where an inter-institutional alliance has been agreed for the sustainability of the proposal, involving personnel from three provincial ministries: (i) justice, (ii) education and (iii) social development, as well as researchers, scientific-technical support staff, Ph.D. students from an R+D+i Institute of Educational Sciences with dual national dependence. In the course of the project, the following activities were carried out: face-to-face group meetings, in-depth interviews with teachers, workshop participants, directors, ministry officials and youth leaders; analysis of institutional documents (regulations and decisions, project descriptions, etc.) and a survey of infrastructure, available technologies (status, quantity) and different types of resources. Two training sessions were also held: (i) a workshop on 4.0 technologies (3D printing, robotics by the group of the research institute for teachers) and (ii) on juvenile justice issues (invited external specialist), a participatory observation of a collective sample of intermedial productions made by young prisoners (audiovisual workshops, press, carpentry, rap, among others), as well as the development of an ad hoc collaborative online platform. Based on a local adaptation of the indicators,

the model proved to be extremely useful in this phase of co-construction to clarify the strengths and weaknesses of the group in the complex inter-institutional agency. All these measures clarify the future action strategies of the DID and the necessary commitments to link the co-construction of technological objects in makerspace-like workshops with the curricular spaces of compulsory education in the context of this center, in order to evaluate the socio-educational scope of the experiences of creative appropriation of technology from the perspective of the institutionalized youth themselves.

Second, because it includes the processes of production and reception of content and artifacts in the study of the processes of technological integration or technological change. It should be noted that this inclusion of artifact production in the analysis is a relevant innovation, since communication studies generally focus on the content produced or the practices of using technologies, but in a study conducted by Siles and colleagues, "only 11.4% of the sample analyzed addressed the production of technology as a subject of study" (2019, p. 19). In this sense, it is essential to integrate new materialities (technical and expressive) into the analytical proposal.

Within the information paradigm, the creation and use of intermedial contents encompasses both material aspects - analog and digital - and multimodal expressive and symbolic elements. Classical pragmatic philosophy (Peirce, 2012) states that it is not possible to distinguish between forms and content in the production of information and knowledge. This means that symbolic production cannot be separated from the technical and expressive qualities of the artifacts. This can be seen, for example, in the new journalistic genres that emerge from the creation of websites, in accounts in digital social networks (González-Esteban & García-Avilés, 2018) or in heritage valorization projects that use computer technologies in the field to create new forms of expression and appropriation of cultural heritage.

Third, because it enables a way of characterization that expresses social processes at the macro and micro levels in one and the same approach. For each object of study, the socio-economic conditions and technical dispositions as well as the socio-cultural needs and technological uses of the social groups involved are recorded (Quinchoa-Cajas, 2020). In the practices of use, appropriation and creation of content and technologies, a multitude of local innovations materialize, which go hand in hand with the expansion of the information paradigm.

Fourth and finally, this model is in line with recent literature, in which multi-method research is one of the main trends in digital communication works (Jensen, 2014) and interdisciplinary studies (Farrow et al., 2020). To address the variables and indicators of this model, it is necessary to develop this type of multi-method

approach, as required by the case of the Juvenile Criminal Responsibility Center. Likewise, analytical metrics and tools to assess interactivity and virtual participation can be used to analyze digital skills and practices in the use of artifacts and technical systems.

CONCLUSION

This paper presents a multidimensional analytical model of the sustainability of dynamic intermedial devices related to technological production and innovation in communication, education and cultural heritage projects. This theoretical-methodological proposal systematizes in one and the same analytical model the material and symbolic variables and indicators that constitute any mediatized communication process. That is, from an integral or cosmopolitan perspective, the link between the study of production and consumption with materiality and content is advanced.

By implementing the four interrelated dimensions in the analysis, it is possible to examine: (i) the dynamic, relational and interactive nature of the functioning of technologies; (ii) the emerging social and political tensions in socio-technical-cultural alliances; (iii) the forms of creation and use that a technology assumes according to the demands and needs of the intervening institutions or projects; and (iv) the modes of production and appropriation of information and knowledge enabled by the technologies and languages used.

One of the conceptual innovations of the model is that both the processes of content creation and appropriation and the production and use of technologies are included in order to assess the socio-technical-cultural sustainability of DID. This represents a significant contribution, as there is little evidence in the literature of integrating these aspects in the same analytical perspective.

Moreover, the model can be adapted to different study cases, and this way of understanding technological development or integration takes into account an interdisciplinary theoretical proposal to develop triangulated or mixed methods. This flexible and interactionist quality contributes to the methodological imagination in communication studies as well as in the social sciences and humanities in general.

The implementation of the model is not limited to the observation of a case, but allows the construction and development of a DID to be methodologically guided. This is because each of the variables and indicators can become necessary conditions to create the conditions for the sustainability of these institutions for communication, education and cultural management. In this sense, the scope and

limitations of the model always refer to a given context that requires adjustments to the indicators and survey methods according to the agreed objectives that generate the DID. In short, the model is understood to be open and flexible in its dynamics of inter-agency co-construction.

Finally, it is crucial to develop theoretical models and flexible and dynamic analytical tools that enable the current manifest changes in the socialities and technicities of different contexts to be taken into account. It is therefore planned to continue the development of this analytical model from implementation to the study of the problem of creative appropriation of 4.0 technologies in different organizations.

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ABOUT THE AUTHORS

GONZALO D. ANDRÉS, has a degree and a Ph.D. in social communication. He is head of the practical work of science problems at the Faculty of Education of the la Universidad Nacional de Entre Ríos. He is a research assistant of Conicet at the Institute of Social Studies (UNER-CONICET). He is dedicated to the study of the changes in the processes of production, circulation and appropriation of knowledge generated by the integration of computer and digital technologies in the pedagogical and academic environment.

https://orcid.org/0000-0003-4993-6080

PATRICIA S. SAN MARTIN, national professor of Music and Doctor of Humanities and Arts. She is a tenured professor of Music Education at the School of Music of the Faculty of Humanities and Arts of the Universidad Nacional de Rosario. Lead researcher of the National Council for Scientific and Technical Research. Director of the Research Institute for Educational Sciences in Rosario (CONICET - UNR).

https://orcid.org/0000-0001-7543-045X

GUILLERMO L. RODRÍGUEZ, mechanical engineer, professor of Philosophy and Ph.D. in Engineering. He is tenured professor of Introduction to Engineering at the Faculty of Exact Sciences, Engineering and Surveying of the Universidad Nacional de Rosario. His research interests focus on modeling methodologies for the analytical study of the monitoring of interactivity processes and the development and optimization of open-source software applications for education, research and technological and social connections.

https://orcid.org/0000-0001-7112-5116