CUADERNOS.INFO Nº 52
Versión electrónica: ISSN 0719-367x
http://www.cuadernos.info
https://doi.org/10.7764/cdi.52.42405

Received: 09-20-2021 / Accepted: 03-03-2022

The audiovisual communication of science in social networks in Costa Rica

La comunicación audiovisual de la ciencia en redes sociales en Costa Rica

A comunicação audiovisual da ciência nas redes sociais na Costa Rica

Margoth Mena Young, Universidad de Costa Rica, San Jose, Costa Rica (margoth.mena@ucr.ac.cr)

ABSTRACT | This research seeks to characterize a sample of 296 science audiovisuals on social networks from ten institutions of the National System of Science and Technology of Costa Rica in 2018 and 2019 and analyze their contribution to spreading scientific knowledge. The study systematized videos published on Facebook, Twitter, YouTube, and Instagram by platform, organization, duration, theme, disciplinary field, protagonists (roles and gender), locations, and others. The results reflect the need to diversify themes and areas of knowledge in audiovisual production, and to include greater narrative resources, as well as gender parity. In addition, there is a low investment in multimedia resources and a need for more personnel dedicated to producing audiovisuals and managing social networks in the organizations studied.

KEYWORDS: science communication; audiovisual; social networks; divulgation; Costa Rica.

HOW TO CITE

Mena Young, M. (2022). La comunicación audiovisual de la ciencia en redes sociales en Costa Rica. *Cuadernos.info*, (52), 91-112. https://doi.org/10.7764/cdi.52.42405

RESUMEN | *Esta investigación tuvo como objetivo caracterizar una muestra de 296 audiovisuales de ciencia en redes sociales de diez instituciones del Sistema Nacional de Ciencia y Tecnología de Costa Rica en 2018 y 2019 y analizar su aporte a la divulgación del conocimiento científico. El estudio sistematizó videos divulgados en Facebook, Twitter, YouTube e Instagram por plataforma, organización, duración, tema, campo disciplinar, personas protagonistas (roles y género), locaciones y otros. Los resultados reflejan la necesidad de diversificar temáticas y áreas del conocimiento en la producción audiovisual y de incluir mayores recursos narrativos, así como la paridad de género. Asimismo, se observa una escasa inversión en recursos multimediales y el apremio por más personal dedicado a producir audiovisuales y manejar redes sociales en las organizaciones estudiadas.*

PALABRAS CLAVE: *comunicación de la ciencia; audiovisual; redes sociales; divulgación; Costa Rica.*

RESUMO | Esta pesquisa teve como objetivo caracterizar uma amostra de 296 audiovisuais de ciência nas redes sociais de dez instituições do Sistema Nacional de Ciência e Tecnologia da Costa Rica em 2018 e 2019 e analisar sua contribuição para a divulgação do conhecimento científico. O estudo sistematizou vídeos publicados no Facebook, Twitter, YouTube e Instagram por plataforma, organização, duração, temática, campo disciplinar, protagonistas (papéis e gênero), localidades e outros. Os resultados refletem a necessidade de diversificar temas e áreas do conhecimento na produção audiovisual e de incluir maiores recursos narrativos, bem como a paridade de gênero. Além disso, observa-se um escasso investimento em recursos multimídia e a urgência por mais pessoas dedicadas à produção de audiovisuais e gestão de redes sociais nas organizações estudadas.

PALAVRAS-CHAVE: comunicação científica; audiovisual; redes sociais, divulgação; Costa Rica.

INTRODUCTION

In the last decade, organizations in the scientific and technological fields have increasingly implemented the use of audiovisuals to relate to their audiences, informing, educating, and entertaining at the same time. As Serrano (2008) states, "memory, knowledge, entertainment, and even relationships and social interaction, are, to a large extent, visually constructed" (p. 246). Cisco's annual Internet report for 2018-2023 highlights that the amount of traffic is growing faster than the number of connections due to the increase in video applications (Cisco, 2020), and adds that the huge demand in homes will be significantly higher for future applications.

As Piñuel Raigada (2020) points out, digital media tend to "audiovisual production and circulation adapted to transmedia and interactive multiscreen versatility" (p. 44).

Such an apogee of images for the field of science communication was demonstrated during the pandemic by COVID-19 (2020-2021), as the volume and complexity of the data had visual representation as its main strategy (Pérez-Montoro, 2021) through photographs, figures, infographics, animations, memes, maps, diagrams, among others. However, there is little evidence to guide the effective use of video to convey complex messages, as well as a lack of studies to understand how best to use this format for effective communication (Røislien et al., 2022).

Digital social networks have diversified content production, forming a "new digital culture based on the audiovisual" (Montero & Mora-Fernández, 2020, p. 325), where those who produce and those who consume alternate their roles in generating content. Science communication is surrounded by this dynamic, striving every day to connect with society on platforms saturated with information and misinformation.

The interest in studying science in the media and educational ecosystem is recurrent from different fields and approaches: on television and science (Cano Orón et al., 2016; Spera et al., 2016), science in videogames (Ouariachisd et al., 2017), social networks and science (Erviti & León, 2014; López, 2014; Fonseca & Mendes, 2021; Shahi et al., 2021), audiovisuals, education, and science (Ezquerra, 2010; Guridi-Colorado, 2010; Grosso, 2017), on scientific documentary (Pérez-Cardozo, 2014; Llinás, 2016), or on science popularization strategies (Seguí et al., 2015), to name a few examples.

This interest is growing with the consolidation of the field of public communication of science (PCS) and multiplied channels for direct contact between organizations and society. PCS "is the practice of recreating scientific information in an accurate

and contextualized way, with reliable and specialized knowledge intended for non-experts (...) [with the] aim of sharing important scientific concepts, notions, theories, and processes with non-scientists" (Castelfranchi & Fazio, 2021, pp. 8-9). Therefore, science communication is a key means to nurture social culture with scientific knowledge and to foster critical attitudes, in association with personal experiences.

In this regard, the population perceives science, technology, and innovation from the interaction with multiple agents: from their family dialogues, their teachers, their visit to a museum, their viewing of a documentary, or their consumption of mass communication. The latter includes social networks which, in the context of the current infodemic, could have a culture effect on people with low media literacy (Igartua & Gerbner, 2002) that would support their distrust of scientific evidence. This growing distrust of data and facts was palpable in the health field during the COVID-19 pandemic (Di Gregori & Sanchez Garcia, 2021; Innerarity, 2021; Lopez Veneroni, 2021; Sánchez, 2021).

Scientific culture is "the set of representations, norms, and values shared by the members of a society and related to scientific activity and knowledge" (Escobar Mercado et al., 2014, p. 191). Its training can be approached from two broad categories: intrinsic and extrinsic (Escobar Mercado et al., 2014; Quintanilla, 2011; Cortassa, 2018; Tapia, 2014).

Intrinsic scientific culture includes scientific knowledge, ethics, and research principles. Extrinsic is used to cover social representations about science, its institutions and agents, along with their cultural, moral, political, or religious assessment.

In this regard, although cognitive deficit is one of the conditioning factors for understanding science-related activities, following Fernández and colleagues (2019), the greater or lesser degree of contact and familiarity with science, access to information, and trust in political and social institutions, as well as the audience's sociodemographic profile (gender, income, age, political ideology, etc.) also play a role.

Similarly, Schäfer and colleagues (2018) separate science communication into attitudes (with cognitive, affective, and conative aspects), people's fears and beliefs, and people's subjective norms regarding science and science communication. López (2016) shares these postulates by stating that scientific culture is a multidimensional phenomenon that encompasses knowledge, attitudes, and behavior, but also affirms that –consequently– the social communication of science must have an impact on cognitive, attitudinal, and behavioral change in people.

There is then consensus on the fact that cognitive components are key, but not unique, elements in science communication studies. Under this premise, this paper seeks to characterize the audiovisual outreach efforts on science in social networks produced from Costa Rica's National Science and Technology System (SNCTI, by its Spanish acronym) in 2018 and 2019, exploring the cognitive and non-cognitive dimensions postulated by Cámara Hurtado and López Cerezo (2007).

- Non-cognitive dimension: covers the person's interest in the topic, expectations, location of interest, distribution of trust, conflicts of expectations, enjoyment, and personal experiences that affect viewing or hinder reception of the message.
- Cognitive dimension: basic knowledge about science and its usefulness, reflection on benefits, risks, adverse effects or controversies, political uses of science, methods used and understanding of scientific jargon, impact on behavioral patterns and dispositions, understanding of obstacles, and economic investment.

The following specific objectives were defined:

- To characterize the institutional profiles that disseminate science audiovisuals of the selected organizations in the four social networks studied, and their management.
- Systematize audiovisual content on science in these institutional profiles.
- Classify the content of the videos linked to the cognitive dimension of scientific culture.

METHODOLOGY

We conducted a content analysis of the audiovisuals on science disseminated in the social network profiles of ten key organizations in the scientific and technological sector of Costa Rica, present in Law 7169 (article 7) that creates the country's National Science and Technology System.

Content analysis can be pragmatic, of sign-vehicle, and of semantic content (Abarca et al., 2013). This work is framed in audiovisual pragmatics according to the following variables: type of social network, profile in the network, cognitive content, audiovisual's theme, disciplinary field, lenght, controversies, risks, denunciations, inclusion, voices/participation by gender, and use of locations.

The institutions are:

- The five public universities: Universidad de Costa Rica (UCR), Universidad Nacional (UNA), Instituto Tecnológico de Costa Rica (TEC), Universidad Estatal a Distancia (UNED), and Universidad Técnica Nacional (UTN).
- The Ministry of Science, Technology and Telecommunications (MICITT, by its Spanish acronym).
- The National Council for Scientific and Technological Research (Conicit, by its Spanish acronym).
- The National Academy of Sciences (ANC, by its Spanish acronym), a non-State public entity.
- The Chamber of Information and Communication Technology (CAMTIC, by its Spanish acronym), the most consolidated private sector association in technology.
- The CIENTEC Foundation, a non-profit organization.

Three additional profiles were introduced during the study, as three of the public universities have fragmented information on science: UNED Investiga, Portal de la Investigación UCR, and Comunicación UNA. Costa Rican public universities provide 76% of public research in the country and at least 60% of the annual investment in scientific and technological development (Ministerio de Ciencia, Tecnología y Telecomunicaciones, 2019).

We analyzed audiovisuals disseminated through the four favorite social networks in Costa Rica: Facebook, Twitter, YouTube, and Instagram. According to the Alexa ranking (www.alexa.com), as of March 2022, the networks with the highest preference in Costa Rica are YouTube in second position, Facebook in third, Instagram in fifth place and Twitter, in twelfth. As a methodological note, it is important to highlight the difficulty of extracting old data on Twitter, since it has a retrieval restriction of 3,200 tweets in total. The retrieval was performed using the Tweet Tunnel tool.

AUDIOVISUALS SELECTION

In the last quarter of 2019, all the audiovisuals shared in 2018 and 2019 by the ten organizations on the four social networks mentioned above were recorded, and we then selected the videos on science. These were divided into deductive (from previous theory) and inductive (from the audiovisual material collected) categories, i.e.: cognitive dimension dissemination and non-cognitive dimension

dissemination; science dissemination (to academic peers), and administrative or management videos. A spreadsheet was used to systematize the videos linked to the cognitive dimension.

We excluded from the content analysis audiovisual materials for dissemination to peers (workshops, scientific conferences), administrative materials (announcements of awards, calls for proposals or invitations (although their quantity was recorded in the initial general mapping), produced outside the country (not original), or in a language other than Spanish.

Likewise, in 2020, seven interviews were conducted through a telematic platform and an online questionnaire to those in charge of social networks to understand the context of production and decision-making on the themes of the videos, their length and focus, as well as the evaluation made of the platforms and human resources allocated to the networks of the communication offices of the NCA, UCR (2), TEC (2), Conicit, and UNED. Due to their low video production, CAMTIC, Cientec, and UTN managers answered specific queries by e-mail.

RESULTS

In the ten SNCTI organizations studied, the social network with the most followers is Facebook, but Instagram surpassed Twitter in number of users. Only the ANC and the MICITT did not have an Instagram profile. In the case of Conicit, it had not published any posts, although it had accumulated followers. The creation of the profile was done to safeguard the name on that social network, but it was not yet incorporated into their digital strategies (Arias, 2020). In the ANC's case, the executive director and her assistant manage the networks, but they lack time, as they are dedicated to other functions (Mora, personal communication, November 2020).

Profiles change names between networks and it is not intuitive to find them. Science is not part of the strategy in the official profiles of universities, with the exception of TEC. This is complex for users, but even more so when the websites of the organizations do not have all the links to the profiles in social networks. Other networks present on some websites were Pinterest (UNED Investiga and UTN), LinkedIn (CAMTIC and UNED), Academia.edu, and SoundCloud (both UNA). Only UNED posted a WhatsApp link.

Of the profiles studied in the four networks, the only one verified was that of the MICITT on Facebook. This guarantees the official profile of the organization, avoids impersonations, and benefits the contents in the search results on the platforms (Facebook, n.d.).

Of the total number of followers accumulated by these organizations on their social networks, 81.6% are on Facebook, 10% on Instagram, 6.8% on Twitter, and only 1.6% on YouTube.

The Universidad de Costa Rica has the largest number of followers on Facebook and Instagram, accounts managed by the Office of Dissemination and Information. The communication account of its Vice Rectory's Office for Research (called *Portal de la Investigación*) was also analyzed; it has little use of Facebook and Twitter, but uses YouTube to host the audiovisual series *Sinapsis*, microprograms with summaries of interviews with research project leaders (Vargas, 2013).

In the case of UNED, their official profiles have very little information about science, a topic covered by the Vice Rectory's Office for Research. On Facebook they have a special profile to disseminate science (*UNED Investiga*), and on YouTube they change its name to *UMBRALES UNED*. It also maintains other profiles on YouTube with a lot of science content which are *Audiovisuales UNED, Videoconferencias UNED*, and *Onda UNED*. In the index of the official website there is no social network, but the page of the Vice Rectory's Office shares the social networks of each of its research units, which facilitates finding them.

Conicit, ANC, Fundación Cientec, and CAMTIC made little use of their spaces on Twitter and YouTube, although they did have activity on Facebook. MICITT had a good number of followers on Twitter, in second place behind TEC, that also does not put on its web index any information about its networks. ANC and Cientec do not have professional support in communication, so their executive directors are in charge of the content and management of their social networks (Mora, personal communication, November 2020). ANC, as well as MICITT and Conicit, have tried to improve their content and design through internships for university students.

UNA had two sites managed from its Communication Office, one more institutional and of political-administrative nature, and the other more journalistic. The latter makes short videos to support its podcasts (extensive interviews) hosted on SoundCloud.

UTN, the youngest of Costa Rica's public universities, founded in 2008, has increased its number of followers on Facebook and even more on Instagram. On its official website it places its link to Facebook, Twitter, and Pinterest, but not to Instagram, despite the mentioned success.

Name	Unit type		Amount / university	Facebook	YouTube	Twitter	Instagram	Total social networks
	Type	#						
TEC	Centers	10	10	2	--	1	--	3
UCR	Centers	34	73	54	26	17	14	111
	Institutes	13						
	Laboratories	2						
	Special units	3						
	Stations, estates, and reserves	21						
UNA	Centers	4	12	12	6	3	4	25
	Institutes	7						
	Laboratories	1						
UNED	Centers	4	10	8	3	4	3	18
	Laboratories	3						
	Program	2						
	Networks	1						
UTN	Unit	1	1	1	--	1	--	2
Total	--	--	106	77	35	26	21	159

Table 1. Profiles in social networks of research units in Costa Rican public universities

Source: Own elaboration.

Public universities (table 1) disseminate their own scientific content for different audiences through 159 spaces in social networks used by the 106 research units. Such is the case of UNA's Vulcanological and Seismological Observatory (OVSICORI, by its Spanish acronym) or UCR's Jardín Lankaster, with profiles that are widely followed on Facebook.

UCR has more centers and additional spaces in social networks, although they are not monitored by the central Communication Office (Mayorga, personal communication, November 2020), and there is no synergy between contents, i.e., it does not work as a digital system of university communication. In the case of TEC, the creation of spaces in networks is limited (Guzmán & Mora, personal communication, November 2020).

Table 1 shows that 72.5% of the total number of research units have an active Facebook profile, and only 33% also have a space on YouTube. The percentage is lower in the other two networks, with 24.5% having a Twitter profile, and just under 20% for Instagram. The people in charge of the communication offices of the universities state that it is not usual for these centers to have professional people in communication. Therefore, research or administrative personnel are usually in charge of the networks, in addition to their functions. Regarding the disciplinary fields of these spaces, a little bit over 60% are basic sciences, natural sciences, and engineering.

Of the total of these research units, 29 do not have any social network (27%), and 29 others only have Facebook, which is the preferred network, followed by YouTube, although there are some very successful ones on Instagram such as UCR's Jardín Lankaster. Only ten units have all four social networks (less than 10%). Ten centers have more than 10,000 followers on Facebook; four have more than 1,000 followers on YouTube and Instagram, and only three have more than that on Twitter.

Science video features

The total number of videos uploaded was 2,476 for the 2018-2019 period. Table 2 shows the number related to scientific knowledge and how many are linked to disseminating scientific culture. To differentiate them, we considered whether or not the content of the video was aimed at a specialized audience and whether the purpose was for people to know about science. Of the total, 47.5% was related to science and, of this, 45% was linked to the cognitive dimension of science communication (21.3% of the total number of videos produced).

Of the 527 outreach videos, 44% were published in more than one social network, so the total number of pieces analyzed was finally 296 videos.

The audiovisual mapping showed that Facebook is the most used social network to distribute videos (between 44% and 51%), closely followed by YouTube. The contribution of Twitter and Instagram in 2018 and 2019 is of little relevance.

ANC dedicates 98% of its audiovisuals to science, but only 50% of its production is in scientific culture, because several of its videos are of specialized topics in broadcasts of long talks recorded live. Almost all of the videos of MICITT and Conicit are related to science (87% and 96%), but they also share calls for proposals, awards, inaugurations, announcements, or political acts that do not have scientific culture as a focus. In the case of Cientec, most of its videos were not original, or were in GIF format and did not provide scientific information.

Institution	Total by organization		Total science-related		Total with scientific education	
	%	#	%	#	%	#
UCR	791	32	32	255	21	163
ANC	61	2.5	98	60	48	29
CIENTEC	13	0.5	100	13	15	2
CAMTIC	59	2.5	97	57	32	19
MICITT	103	4	87	90	17	18
CONICIT	67	2.5	96	64	9	6
UTN	156	6.5	8	13	1	1
TEC	305	12.5	34	103	25	75
UNED	396	16	88	348	39	155
UNA	525	21	33	172	11	59
Total	2,476	100%	47.5	1,175	21.3	527

Table 2. Audiovisuals published in social networks by Costa Rica's SNCTI and their relationship with science

Source: Own elaboration.

As for CAMTIC, they mentioned doing Facebook Live broadcasts when needed, or hiring affiliated companies for their recordings, but without a guideline or plan (Angulo, personal communication, November 2020). None of these organizations have professional support in communication or audiovisual production in their staff.

Table 2 also shows that public universities produce more science audiovisuals, but most of these videos are not planned (script, objectives, and resources); instead, they come from the academic and research activities of their schools or centers. For example, from congresses, training, interviews with experts, opening ceremonies, or press conferences. Although UCR produced more audiovisuals, only 27% are related to scientific knowledge and 12% have some relation to scientific culture. UNED, through its Vice Rectory's Office for Research, was the one that contributed the most to scientific culture, whose objective is to reach non-specialized audiences with a vision of gender inclusion (Umaña, personal communication, November 2020).

Of the 1175 science-related videos, 152 (13%) had administrative or institutional objectives, 225 (19%) were intended for academic peers, 271 (23%) corresponded to non-cognitive messages, and 527 (45%) were knowledge or learning content.

As a complement to the data on institutional profiles, the research units of public universities also disseminated 1,303 science videos: 815 on Facebook and 445 on YouTube, i.e., almost 97% of the videos were disseminated on these two networks. It should be considered that many units do not have Twitter (75.5%) or Instagram (80%). TEC and UTN units did not publish any videos.

Video distribution by area

Basic Sciences were the most represented (figure 1), followed by Technology. Within Basic Sciences, Biology was by far the most represented, followed by Chemistry, Geology (Tectonics, Volcanology, Hydrology) and Astronomy. In Technology, the majority was in robotics (shared with Engineering), simulators, and the work of UNED's FabLab. The CAMTIC videos contributed greatly to this category.

The dissemination of studies on pollution, biodiversity, climate change, forest fires, and ecosystems (related to Biology) is currently booming and sustains this third place for the Environment category. The focus on conservation and environmental wellbeing led to the opening of this category, which does not correspond to the classifications of areas or faculties of public universities in Costa Rica.

A total of 69 videos dealt with more than one disciplinary field, i.e., 23% of interdisciplinarity. The most mixed were Basic Sciences (mostly Biology), Environment, Health Sciences, Engineering, and Technology. Despite the national and university policy to promote the STEM area, there is very little dissemination of Mathematics and Engineering. Science policy was directly addressed only by MICITT and CAMTIC.

Health Sciences, usual content in media coverage analysis in journalism and television, did not appear in the first places of this study. Social Sciences were addressed by UNED and UCR to a greater degree, and the only audiovisual in Art was by UCR, as a result of a research and development process of a non-toxic engraving technique in leather that resulted in a patent in 2018. TEC and UNED were the ones that produced audiovisuals in Engineering and, along with UCR, contributed to the registry for the agri-food segment. It is striking that only UNED approached education from scientific research. In consultation with the UCR on this matter, it was stated that it has assigned journalists by disciplinary area and the one who covers education works part time (Mayorga, personal communication, November 2020).

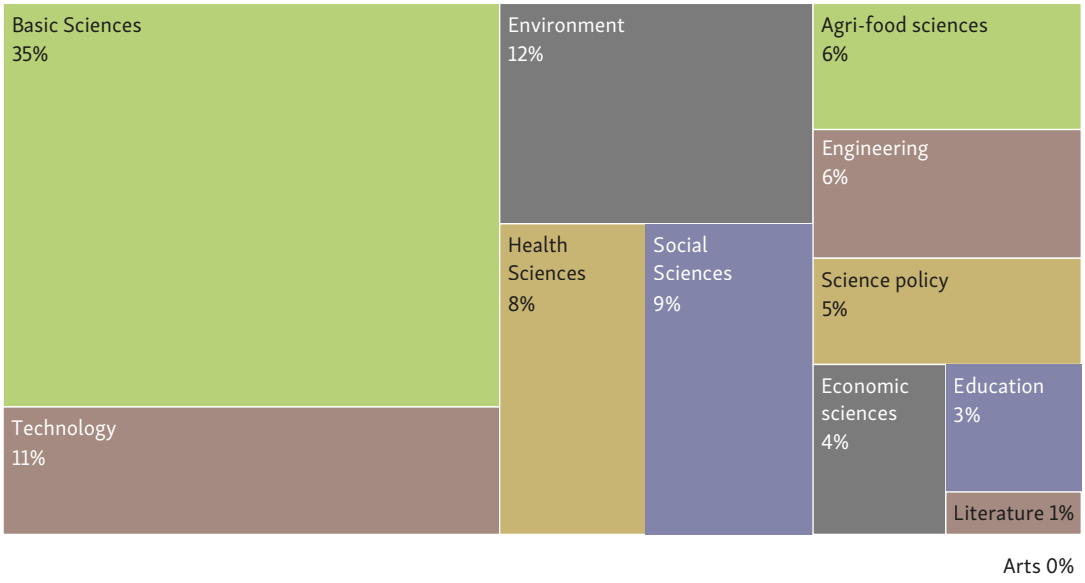

Figure 1. Ranking of science audiovisuals in social networks according to their disciplinary field

Source: Own elaboration.

Education, Arts and Letters are relegated in the production of audiovisuals, despite the fact that all areas have research centers in four of the five universities.

This study also analyzed the presence of women in the pieces analyzed. Table 3 shows the classification by gender of people who gave statements or made voiceovers in the videos.

The largest gap was in authorities: 44 people in leadership positions were heard, only eight were women. In the business dimension there is a notorious imbalance, mostly from the CAMTIC videos, with a majority of male voices on the technology industry.

Table 3 also shows the low presence of civil society and students, which promotes a gap between the broadcasting elites who create or possess the knowledge and those who only receive the message. This lack of voices from common attributes and selfhood threatens dissemination among audiences with distrust in the political system or formal structures.

In the press, men appeared more often with a microphone or mobile phone and women as narrators. Within the student population, more men were captured on camera in the tours, especially in the UNED videos, which gave more space to students in an active role.

Audiovisual presence	Men		Women		Total	
	#	%	#	%	#	%
Research/expertise	286	64.1	160	35.9	446	52.8
Political authority positions	36	81.8	8	18.2	44	5.2
Journalists/narration	53	51.5	50	48.5	103	12.2
Businessmen/businesswomen	78	79.6	20	20.4	98	11.6
Civil society/beneficiaries	59	58.4	42	41.6	101	12.0
Students	31	58.5	22	41.5	53	6.3
Total	543	64,3	302	35,7	845	100

Table 3. Active voice in science videos on social networks by gender

Source: Own elaboration.

In terms of institutions, the only organization that presents a majority of women is MICITT (61.5%), since for the World Day of Girls and Women in Science it produces videos on the subject, an action that is not maintained throughout the year. Also noteworthy is an animated series produced by UNED dedicated to vocations, based on testimonies of women scientists.

Regarding the use of exteriors or interiors in the videos, almost 58% were recorded indoors, although 8% had the presence of both interiors and exteriors, changing locations. This is consistent with the aforementioned scarcity in the planning and allocation of resources for audiovisual production in the dissemination of science in these organizations.

Indoor use (42%) was traditional: offices, laboratories, auditoriums, schools, homes, radio booths, or organization corridors. The exteriors, on the other hand, are diverse: gardens, forests, rivers, seas, lakes, boats, volcanoes, highways, rural roads, soccer fields, recreational parks, views with drones, etc. UNED was the only organization with a majority of outdoor audiovisuals (53%). Several have more than 65% indoors (UTN, MICITT, Conicit, ANC, and CAMTIC). An additional fact is the non-inclusion in this classification of the 31 animated videos (almost 6% of the total number of cognitive science videos).

Although universities can easily portray science outdoors, the resource is still scarce. TEC, for example, has four defined areas: marketing and public relations, content management, institutional web, and audiovisual production (Guzmán & Mora, personal communication, November 2020). Their full team is around 25 people, of which only two are dedicated to audiovisual. During the study period, they hired an external production company for videos that included their regional headquarters and the impact on their beneficiaries.

In UCR's case, the Dissemination Office has 35 professionals, but there is only one person who works part-time in audiovisuals, so they favor infographics and photographs with text or sound, as they have eight professionals in graphic design (Mayorga, personal communication, November 2020). At UNED there is only a team of three people in the Vice Rectory's Office for Research and only one is in audiovisual production (Umaña, personal communication, November 2020). UTN does not have specific audiovisual production for science (Barrantes, personal communication, November 2020).

This lack of evolution in human resources, in terms of digital communication needs, has also led to the hiring of private companies to manage social networks; at UCR, for example, "there is no systematized practice of responding to comments or answering queries" (Mayorga, personal communication, November 2020). The same happens in other organizations, although in CAMTIC, Cientec, ANC, or Conicit, for example, the follow-up depends on the interest of the person who makes the publication. In TEC there is a team to manage the web and institutional social networks.

The study also analyzed the general treatment of science in terms of benefits, risks, claims, complaints, and controversies: almost 76% of the videos addressed the benefits of research and the positive science results of the organizations. There were no records of risks linked to scientific processes or risks for researchers, but of the subject itself (22%); for example, when talking about forest fires (loss of flora and fauna and changes in ecosystems) or antivenin serum (deaths and consequences of snake bites).

The demands were present in some interviews conducted by the UCR on the occasion of the 2018 presidential elections: one requested a new water management law and the other stated that an environmental agenda should be a priority in a next government, considering as number one the management of plastic solid waste.

Only three videos contained denunciations: in one, the UCR mentioned that the country's energy still comes from fossil fuels. A UNED video announced the death of a pair of *jabirús* (birds) due to illegal hunting, and another one was about hunting and vandalism as causes of forest fires.

Science controversies are not addressed or explained to encourage citizen participation. The only subtle controversy documented was the evidence that fires do not affect an ecosystem equally and that there are adaptive resprouts after fires, in a UNED video.

Regarding the duration of the 296 videos studied, 54 were less than one minute (18%), 116 were between one and three minutes (39%), 23 were between three and

four minutes (8%), 47 were longer than four minutes and up to ten (16%), 36 were between ten minutes and one hour (12%), and 20 lasted more than one hour (7%). Almost 35% of the pieces lasted more than four minutes and were related to live transmissions and interviews.

As a final point, the inclusion of people with disabilities was not part of the audiovisual exercise on science in Costa Rica in those two years, neither in the videos nor in support resources in their production: only one UNED video includes a box for the Costa Rican Sign Language.

DISCUSSION AND CONCLUSIONS

Although the multiple spaces in social networks have opened great opportunities to interact directly with the audience, they have also fueled infodemia. An excessive amount of information on the Internet challenges science communication to establish relationships, make the product and the message effectively consumed, ensure trust, and achieve its adoption. This is evident in the number of profiles opened by SNCTI organizations and research units of public universities in Costa Rica.

These organizations have engaged in digital communication, some with a large number of followers (such as public universities) and others, with more specific niches (ANC and MICITT, for example), but knowing the audiences and evaluating their consumption goes beyond the metrics of each platform; it is a road yet to be traveled and a requirement for managing science communication.

People in charge of communication need to be updated in digital communication, as well as in science communication. Infodemia also provokes the need to create innovative narratives, with stories that incorporate science in them. It is necessary to anticipate changes and reflect on strategic actions to make social networks a reliable means of interaction: Instagram, for example, has 67% of users equal to or younger than 34 years old (Fernández, 2021), and Facebook is losing teenage users. It is projected that by 2022 it could reduce to 60.2% of the total number of Internet users (McNair, 2018).

The percentage obtained in audiovisuals for the cognitive scientific culture shown here can improve, it has been growing over the years, and it is expected that this trend will continue, but there is still a debt with several disciplinary fields. The Arts, Letters, Social Sciences, and Education had a scarce presence in videos and synergy is necessary to advance in their digital representation.

Stories have little presence in the audiovisuals studied, with the exception of certain testimonies, which are more autobiographical than of cognitive dissemination. Most of the videos maintained a journalistic style; in others, institutional reputation was built. There is a marked difference between promoting science and using it for branding purposes. The former approach will eventually add to the latter, but the planning of content, spokespersons, and messages is different depending on the objective. The use of storytelling for science is possible, but is still pending.

There are differences in the approaches to the use of science in audiovisuals: interest in showing transparency (how public money is invested, for example); disseminating science for reputational purposes; raising positive public opinion; seeking political positioning; advertising purposes (congresses, conferences, openings, closings, etc.); disseminating to academic peers, or getting people to know, enjoy and use scientific knowledge.

The large production of the research units of public universities goes unnoticed and, although they are concerned about maintaining profiles in social networks, an important part lacks close support in communication, as was found in the interviews. It is important to strengthen synergy spaces in organizations from the first level to communicate as a national science system.

An additional aspect is the traffic overlap between the social networks used, which have their own features and audiences, so their use should be strategic. Innovative content should be provided, because those who are loyal followers in several networks will find the same content, as evidenced by the percentage of duplicate videos. The decision of when and how to repeat a visual product should be based on knowing the user population or according to a segmented pattern. Globally, 73% of Facebook users also access Instagram, 72% YouTube, and 65% Twitter (www.alexa.com).

Regarding the length of the videos, the longest were interviews or live transmissions of academic/political activities from Facebook Live, a modality rewarded by the network's algorithm, which boosts the content's visibility, but is not very useful for capturing the uninterested audience, i.e., this format does not work in scientific culture. Very short videos (less than 30 seconds) have an effect of curiosity, entertainment, or promotion, but fail to convey knowledge. Although it is a good resource, it cannot be the only one, since there would be no theoretical-methodological training of the audiences.

A key point in the results was to analyze the binary gender parity: men dominated in all categories, with greater proportion in specialists, businessmen,

and authorities. Networks, part of the media ecosystem, are key agents to maintain or break stereotypes and open access. It is also essential to think about scientific vocations. The barriers that women feel in choosing a career in STEM are well known and –even more so– illustrated when observing the gap between income and graduations (Gloria Bonder, cited by Costa & Tombesi, 2019). In Costa Rica, female graduates in Mechanical Engineering are only 8%; Electronic and Electrical Engineering, only 12% (INAMU, n.d.). New voices should also be incorporated and the approach should be modified when recording with scientific people, to work from the selfhood when sharing knowledge.

The continuous presence in videos of researchers or people in positions of authority or leadership as the only active voice for scientific content stands out, which proves the use of the authority principle as a persuasive technique, and perpetuates the gap between the scientific class and the citizenry (sense of otherness).

The excess of information, the multiplication of opposing or misleading voices, and the loss of legitimacy of authorities and the media are nourished daily by social networks. These also open spaces to build a citizen-based public discourse and to access scientific knowledge easily: that which has been current for years, that which has recently been discovered, that which seeks innovation, or that which is surrounded by controversy (Mena, 2020).

In this regard, the fight against misinformation and pseudoscientific content is a priority, and organizations in the scientific and technological sector are called upon to act to make evidence-based information visible, based on novel, attractive, entertaining, and useful content. The challenge is neither easy nor small, but it is a duty to assume it for the benefit of our current and future societies.

FUNDING

These results were obtained as part of the project B9358 *Narrativa en productos audiovisuales en la Comunicación Pública de la Ciencia en Costa Rica* (B9358 Narrative in Audiovisual Products in the Public Communication of Science in Costa Rica), which runs from 2019-2021, and was funded by the Vice-Rectory of Research of the Universidad de Costa Rica and registered in the Communication Research Center (CICOM, by its Spanish acronym) of the same university.

REFERENCES

Abarca, A., Alpízar, F., Sibaja, G., & Rojas, C. (2013). *Técnicas cualitativas de investigación* (Qualitative Research Techniques). Editorial UCR.

Cámara Hurtado, M. & López Cerezo, J. A. (2007). Dimensiones de la cultura científica (Social appropriation of science). In *Percepción social de la ciencia y la tecnología en España 2006* (Social perception of Science and Technology in Spain, 2006) (pp. 39-64). FECYT. https://www.fecyt.es/es/publicacion/percepcion-social-de-la-ciencia-y-la-tecnologia-en-espana-2006

Cano-Orón, L., Portalés Oliva, M., & Llorca-Abad, G. (2016). La divulgación de salud en la televisión pública, el caso de RTVE en 2016 (Popularization of health in public television: the case of RTVE in 2016). *adComunica: Revista científica de estrategias, tendencias e innovación en comunicación,* (14), 201-228. https://doi.org/10.6035/2174-0992.2017.14.11

Castelfranchi, Y. & Fazio, M. E. (2021). Comunicación pública de la ciencia (Public Communication of Science). UNESCO.

Cisco. (2020, March 9). Cisco Annual Internet Report (2018–2023) White Paper. *Cisco*. https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html

Cortassa, C. (2018). La identidad del campo de Comunicación de las Ciencias en América Latina (The identity of the Science Communication field in Latin America). *Journal of Science Communication – America Latina, 01*(01), 1-10. https://doi.org/10.22323/3.01010401

Costa, C. & Tombesi, C. (2019, March 8). Día de la Mujer: 6 gráficos que muestran cómo avanzaron (o no) las mujeres en América Latina (Women's Day: 6 figures that show how women have advanced (or not) in Latin America). *BBC News Mundo*. https://www.bbc.com/mundo/noticias-america-latina-47490978

Di Gregori, C. & Sánchez García, V. (2021). El culto a la irracionalidad como forma de negacionismo. Expresiones públicas en tiempo de pandemia (The cult of irrationality as a form of denial. Public expressions in times of pandemic). In M. C. Di Gregori & F. López (Coords.), *Contagios y contiendas: Hacer ciencia, arte y filosofía en pandemia* (Contagions and conflicts: Doing science, art, and philosophy during a pandemic) (pp. 21-36). EDULP. http://sedici.unlp.edu.ar/handle/10915/130042

Erviti, C. & León, B. (2014). La comunicación de la ciencia a través del vídeo online: contenidos populares en YouTube (Communicating science through online video: popular content on YouTube). In J. Sierra & D. Rodrigues (Coords.), *Contenidos digitales en la era de la sociedad conectada* (Digital contents in the connected society era) (pp. 129-146). Fragua.

Escobar Mercado, M., Quintanilla Fisac, M. A., & Santos Requejo, L. (2014). Indicadores de cultura científica por comunidades autónomas (Indicators of scientific culture by autonomous communities). In C. Torres Albero (Ed)., *Percepción social de la ciencia y la tecnología* (Social perception of science and technology) (pp. 190-215). FECYT.

Ezquerra, Á. (2010). Desarrollo audiovisual de contenidos científico-educativos. Vídeo: «Las vacas no miran al arco iris» (Audiovisual production of scientific-education contents. Video: "Cows Do Not Look At The Rainbow"). *Enseñanza de las ciencias, 28*(3), 353–366. https://raco.cat/index.php/Ensenanza/article/view/210805

Facebook. (2021). Información sobre la verificación (Information about verification). *Facebook*. https://www.facebook.com/business/help/1095661473946872?id=180505742745347

Fernández, R. (2021, February 17). Distribución por edad de los usuarios mundiales de Instagram en 2021 (Percentage distribution by age of Instagram users in 2021). *Statista*. https://es.statista.com/estadisticas/875258/distribucion-por-edad-de-los-usuarios-mundiales-de-instagram/

Fernández, M., Cárdenas, J., & Sánchez, M. I. (2019). El estatus científico de profesiones y prácticas: una comparación entre ciencias experimentales, ciencias sociales y pseudociencias (The scientific status of professions and practices: a comparison between experimental sciences, social sciences and pseudosciences). In *Percepción Social de la Ciencia y la Tecnología 2018* (Social Perception of Science and of Technology 2018) (pp. 109-139). FECYT. https://www.fecyt.es/es/system/files/publications/attachments/2020/02/percepcion_social_de_la_ciencia_y_la_tecnologia_2018_completo_feb.pdf

Fonseca, A. A. & Mendes, L. (2021). Breve panorama da divulgação científica brasileira no YouTube e nos podcasts (Brief Overwiev of Brazilian Science Communication on YouTube and Podcasts). *Cadernos De Comunicação, 25*(2). https://doi.org/10.5902/2316882X63121

Grosso, J. (2017). *Ciencia en televisión: las estrategias divulgativas del programa "Redes 2.0" de Eduard Punset (TVE, 2008-2013)* (Science on television: the informative strategies of the program "Redes 2.0" by Eduard Punset (TVE, 2008-2013)) (Doctoral dissertation, Universidad de Granada, España). https://digibug.ugr.es/handle/10481/47521

Guridi-Colorado, J. J. (2010). *El discurso audiovisual en la divulgación de la ciencia de la UNAM: la construcción de un modelo de ciencia para divulgar* (Audiovisual discourse in the dissemination of science at UNAM: the construction of a science model to disseminate) (Master's Thesis, ITESO). https://rei.iteso.mx/handle/11117/2418

INAMU. (n.d.). Ciencia, Tecnología y Género (Science, Technology and Gender). *INAMU.* https://www.inamu.go.cr/ciencia-tecnologia-y-genero

Igartua, J. J. & Gerbner, G. (2002). Violencia y televisión: nuestro medio ambiente cultural. Entrevista con George Gerbner (Violence and television: Our cultural environment. Interviewing George Gerbner). *Cultura y Educación Culture and Education, 14*(1), 55-61. https://doi.org/10.1174/113564002317348110

Innerarity, D. (2021). La pandemia de los datos (The Data Pandemic). *DILEMATA, Revista Internacional de Éticas Aplicadas*, *35*, 67-72. https://cadmus.eui.eu/handle/1814/73090

Llinás, D. (2016). *La convergencia tecnológica audiovisual y la divulgación científica* (Audiovisual technological convergence and scientific dissemination) (Doctoral dissertation, Universidad Complutense de Madrid). http://eprints.ucm.es/38105/1/T37379.pdf

López, C. (2014). La interrelación entre las redes sociales específicas de la comunicación científica y las redes sociales de uso general (The inter-relation between specific social networks for scientific communication and general use of social networks). *Vivat Academia*, (127), 103-116. https://doi.org/10.15178/va.2014.127.103-116

López, J. A. (2016). *Cultura científica y comunicación social de la ciencia. Cátedra CTS Paraguay* (Scientific culture and social communication of science. CTS Paraguay Chair).

López Veneroni, F. (2021). De la pandemia a la infodemia: el virus de la infoxicación (From Pandemic to Infodemic: The Virus of Infoxication). *Revista Mexicana de Ciencias Políticas y Sociales, 66*(242), 293-312. https://doi.org/10.22201/fcpys.2448492xe.2021.242.79330

McNair, C. (2018). *US Social Network Users: eMarketer's Estimates for 2018–2022*. eMarketer. https://www.emarketer.com/Report/US-Social-Network-Users-eMarketers-Estimates-20182022/2002222

Mena, M. (2020, September 29). Las redes sociales, la información pública y la ciencia: asumir el reto es posible (Social networks, public information and science: assuming the challenge is possible). *UNESCO*. https://es.unesco.org/news/opinion-redes-sociales-informacion-publica-y-ciencia-asumir-reto-es-posible

Ministerio de Ciencia, Tecnología y Telecomunicaciones. (2019). Indicadores Nacionales de Ciencia, Tecnología e Innovación, Costa Rica 2018 (National Indicators of Science, Technology and Innovation, Costa Rica 2018). *MICITT*. https://www.micitt.go.cr/micitt/publicaciones/indicadores-ciencia-y-tecnologia

Montero, A. & Mora-Fernández, J. (2020). La democratización de la comunicación interactiva y el lenguaje audiovisual en YouTube: ¿tipologías evolutivas en la cultura y humanidades digitales? (The democratization of audiovisual media and its consequences in the contemporary image). *RISTI-Revista Ibérica de Sistemas e Tecnologias de Informaçao*, *26*, 323-334.

Ouariachi, T., Olvera-Lobo, M. D., & Gutiérrez-Pérez, J. (2017). Evaluación de juegos online para la enseñanza y aprendizaje del cambio climático (Evaluation of online games for teaching and learning on climate change). *Enseñanza de las ciencias: revista de investigación y experiencias didácticas*, *35*(1), 193-214. https://raco.cat/index.php/Ensenanza/article/view/319575

Pérez-Cardozo, N. A. (2014). *El documental científico. Procesos de recontextualización discursiva en la divulgación de la ciencia* (The scientific documentary. Processes of discursive recontextualization in the popularization of science) (Master's Thesis, ITESO). https://rei.iteso.mx/bitstream/handle/11117/2522/nestor_perez_cardozo.pdf?sequence=2

Pérez-Montoro, M. (2021). Comunicación visual de una emergencia sanitaria mundial: el caso de la Covid-19 (Visual communication of a global health emergency: the case of Covid-19). *Anuario ThinkEPI, 15*, e15d01. https://doi.org/10.3145/thinkepi.2021.e15d01

Piñuel, J. L. (2020). Noción de verdad en los discursos mediáticos y digitales ante los desafíos para la comunicación en democracia (Notion of truth in media and digital speeches to the challenges for communication in democracy). *index.comunicación, 10*(3), 23-72. https://doi.org/10.33732/ixc/10/03Nocion

Quintanilla, M. Á. (2011). La ciencia y la cultura científica (Science and Scientific Culture). *ArtefaCToS. Revista de Estudios sobre la Ciencia y la tecnología, 3*(1), 31–48. https://revistas.usal.es/index.php/artefactos/article/view/8428

Røislien, J., O'Hara, J. K., Smeets, I., Brønnick, K., Berg, S. H., Shortt, M. T., Lungu, D. A., Thune, H., & Wiig, S. (2022). Creating Effective, Evidence-Based Video Communication of Public Health Science (COVCOM Study): Protocol for a Sequential Mixed Methods Effect Study. *JMIR Research Protocols*, *11*(3), e34275. https://doi.org/10.2196/34275

Sánchez, A. N. (2021). Desinformación y Covid-19: Análisis cuantitativo a través de los bulos desmentidos en Latinoamérica y España (Disinformation and Covid-19: Quantitative analysis through the hoaxes debunked in Latin America and Spain). *Estudios sobre el Mensaje Periodístico, 27*(3), 879-892. https://doi.org/10.5209/esmp.72874

Seguí, J. M., Poza, J. L., & Mulet, J. M. (2015). *Estrategias de divulgación científica* (Science Dissemination Strategies). Editorial Universitat Politècnica de València. http://hdl.handle.net/10251/53145

Serrano, A. (2008). El análisis de materiales visuales en la investigación social: el caso de la publicidad (The analysis of visual materials in social research: the case of advertising). In A. Gordo & A. Serrano (Eds.), *Estrategias y prácticas cualitativas de investigación social* (Social research qualitative strategies and practices) (pp. 245-286). Pearson Educación.

Shahi, G. K., Clausen, S., & Stieglitz, S. (2021). Who shapes crisis communication on Twitter? An analysis of influential German-language accounts during the COVID-19 pandemic. *arXiv: Social and Information Networks,* arXiv:2109.05492. https://doi.org/10.48550/arXiv.2109.05492

Schäfer, M., Füchslin, T., Metag, J., Kristiansen, S., & Rauchfleisch, A. (2018). The different audiences of science communication: A segmentation analysis of the Swiss population's perceptions of science and their information and media use patterns. *Public Understanding of Science, 27*(7), 836-856. https://doi.org/10.1177/0963662517752886

Spera, A., Andrade, H., & Murriello, S. (2016). TV, ciencia y tecnología, una transformación mutua (TV, science and technology, a mutual transformation). *Revista de Investigación del Departamento de Humanidades y Ciencias Sociales, 2*(8), 25-46. http://repositoriocyt.unlam.edu.ar/handle/123456789/633

Tapia. P. (2014). *Consideraciones para la definición y medición de la Cultura Científica en Chile. Propuestas para la Primera Encuesta Nacional de Cultura Científica y Tecnológica en Chile* (Considerations for the definition and measurement of Scientific Culture in Chile. Proposals for the First National Survey of Scientific and Technological Culture in Chile). CONICYT. https://www.conicyt.cl/wp-content/uploads/2014/07/Informe-de-Resultados-Comisi%C3%B3n-Nacional-en-Cultura-Cient%C3%ADfica.pdf

Vargas, M. (2013, June 26). Programa semanal difundirá avances científicos y tecnológicos de la UCR (Weekly emission will spread UCR's scientific and technological advances). *La Nación.* https://www.nacion.com/ciencia/aplicaciones-cientificas/programa-semanal-difundira-avances-cientificos-y-tecnologicos-de-la-ucr/LAZP4YGQDZGNVDJPS2KK2CCKW4/story/

ABOUT THE AUTHOR

MARGOTH MENA YOUNG, Ph.D. in Communication from the Universidad de Málaga, Spain. She is a researcher in Public Communication at the Center for Communication Research (CICOM, by its Spanish acronym) of the Universidad de Costa Rica (UCR); academic coordinator of the Public Relations section, and professor in Communication Research at the School of Communication Sciences (ECCC) of the same university.

https://orcid.org/0000-0002-9495-9081