



Scripting the research process: didactic transposition and narrative design for a short documentary film around laboratory analysis of coastal sediments in Uruguay

Paulina Abre¹, Francisco Lugo², Gonzalo Blanco¹

5 ¹Departamento de Geociencias, Centro Universitario Regional Este, UdelaR, Treinta y Tres, 33000, Uruguay

²División Científica de Geología, Museo de La Plata, UNLP, La Plata, CP 1900, Argentina

Correspondence to: Paulina Abre (pabre@cure.edu.uy)

Abstract. Geological literacy is critical for addressing modern socio-environmental challenges, yet geosciences remain marginalized within pre-university curricula globally due to the abstract nature of their processes and significant visualization barriers. This study examines a replicable framework for public science communication through the design, production, and multi-channel evaluation of the 17-minute place-based documentary “Arena negra, un misterio oculto en las playas de Uruguay”. Grounded in Place-Based Education (PBE) and Didactic Transposition frameworks, the scientific script was structured around a multi-scale narrative progression that transitions dynamically from macroscopic coastal landscapes down to laboratory processing (gravimetric and electromagnetic separation) and microscale single-grain mineralogical analysis using an electron microscope. Evaluation metrics over a 566-day digital tracking window yielded 35,704 views and 3124 cumulative playback hours. Algorithmic analysis revealed that 77.2% of views were driven by YouTube’s Browse Features, indicating that the video successfully bridged a latent content-demand gap regarding regional Earth Sciences. Unexpectedly, hardware, metrics showed that Smart TVs were the dominant playback device (62%), and demographic data indicated an inverted age profile where citizens ages 65 and older represent the primary consumer group. Qualitative analysis of user comments revealed deep-seated misconceptions regarding sediment color as well as environmental concerns that were successfully mitigated by the videos action-oriented pedagogical strategies and cultural analogies. Ultimately, this intervention demonstrates that translating rigorous laboratory workflows into dynamic, localized storytelling serves as a highly cost-effective, regional environmental awareness in territories with limited formal scientific infrastructure.

25 **Keywords**

Educational Media Design, Geosciences Communication, Placed-Based Education, Didactic transposition, coastal management



1. Introduction

Geosciences literacy aims to empower citizens to address modern challenges such as land management, natural hazard prevention, and energy transition through the acquisition of Earth Science knowledge. Nonetheless, this cross-disciplinary field entails highly abstract concepts and processes that present significant visualization barriers for the non-expert. Consequently, despite its vital role in strategic sectors and its demonstrable cultural and socio-environmental value, the geosciences remain marginalized within pre-university curricula globally, with Uruguay being no exception. This lack of institutional prominence fails to stimulate early interest, leaving the general public with scarce knowledge and low engagement with Earth Sciences (Martínez Braceras et al., 2022). Due to this educational deficiency, citizens are vulnerable to misconceptions about the processes shaping their territory and daily life, while simultaneously hindering public understanding of resource availability (Delgado & Calonge, 2018; Brusi & Calonge, 2025).

Public communication of geosciences in Latin America, and specifically in Uruguay, faces the challenge of translating highly technical concepts into accessible language for non-expert audiences. Topics such as the formation of sedimentary rocks, heavy mineral transport and beach evolution are central to understanding coastal dynamics, yet they are frequently perceived by citizens as abstract, academic and detached from daily life. This persistent gap between academic knowledge and society limits the public valuation of coastal geological heritage. Furthermore, in Uruguay, opportunities for the general public to engage with scientific literacy outside the formal education system remain limited, primarily due to the scarcity of science museums, exhibitions, national parks and geoparks, a deficiency that is even more pronounced in the interior of the country.

Unlike other scientific fields, communication within the geosciences is constrained by inherent characteristics, such as explaining phenomena operating on dynamic, non-linear, and complex systems with high degrees of uncertainty and chaotic variables (Wang et al., 2022). These factors can overwhelm working memory if communicative strategies fail to intentionally minimize cognitive demands (Lacchia et al., 2020). Recent studies emphasize that analyzing the didactic transposition within video scripts is crucial for effective public engagement in the geosciences, suggesting that a 15-minute video length is ideal to achieve a thorough explanation of targeted topics (Mingo Zapatero & García Guinea, 2025). However, geoscience communication is also limited by its geographic contingency; public interest varies significantly across spatial regions due to distinct localized cultures, risk perceptions, and belief systems (Wang et al., 2022), pointing to the need for place-based frameworks that adapt scientific content to regional realities (Littrell et al., 2019; Pavelle & Wilkinson, 2020).

In recent years, short audiovisual formats have established as powerful tools for informal scientific outreach, offering clear pedagogical advantages over text and static graphics for the non-expert audience (Nisbet et al., 2010). With over two billion monthly authenticated users and nearly 500 hours of content uploaded every minute, YouTube has emerged as one of the most pervasive video-sharing platforms for global science communication (Velho and Barata, 2020), and an effective online learning medium (Rahmatika et al., 2021). This digital reach is particularly relevant in Uruguay, where



online penetration stands at 93% with 3.15 million active internet users, including 2.4 million localized YouTube users (Kemp, 2025). These digital platforms enable researchers to reach broad, non-expert audiences and sustain public attention by combining clear narrative structures with visual explanations of geological processes. The role of science documentaries in citizen education focuses not merely on formal conceptual learning, but rather on sparking an interest in science and drawing attention to its impact on daily life (Sancho Úbeda, 2009), especially as citizens increasingly utilize videos for autonomous learning on portable devices. Moreover, face-to-face screenings serve as powerful mechanism for non-expert motivation and societal empowerment, bridging the gap between community dialogue and science communication (Rooney-Varga et al., 2014).

This paper presents the design and evaluation of the short-documentary entitled “Arena negra: un misterio oculto en las playas de Uruguay” (Black sand: a hidden mystery on the beaches of Uruguay). The short documentary was optimized to maximize viewer engagement across both digital social media and face-to-face screenings. The project strategically utilizes place-based education (PBE) by anchoring the narrative to recognizable local landscapes, specifically the beaches of Rocha and Maldonado Departments in Uruguay. PBE leverages the emotional attachment of people to familiar geographic places to enhance their internal motivation to learn, overcome abstraction barriers and foster a strong cognitive connection (Littrell et al., 2019). Categorized as a narrative explanatory film (Boy et al., 2020), the short documentary is built around a central question (the mystery of the black sands) and develops through a logical sequence of evidence providing clues to explain the main topic. This format allows the narrative to seamlessly span both macro- and micro-scales (Bergillos Ruíz, 1993), traveling visually from the landscape of the beach down to the chemical composition within a single grain of sand.

The primary objective of this study is to analyze how the integration of public communication of science and didactic transposition can balance cognitive engagement with storytelling to translate rigorous, abstract geological concepts into accessible public knowledge. Specifically, this paper evaluates the effectiveness of the audiovisual design in promoting scientific literacy, explaining the socio-environmental value of coastal geology, and empowering citizens for environmental decision-making. By examining this place-based intervention, this research aims to provide a replicable framework for geosciences communication in regions with limited formal and informal educational infrastructure.

2. Methodology

2.1 Audiovisual design and conceptual framework

The narrative design and audiovisual production of the short documentary followed the methodological recommendations of Boy et al. (2020), and Beauteemps and Bresges (2021) for the creation of multimodal science communication videos. This framework integrates synchronized visual and verbal functional elements, including still images, localized footage, on-screen text, immersive soundscapes, expert interviews, and real-time laboratory experimentation.



The scientific script organizes information in a zoom format, starting with the viewer's everyday perception of coastal landscapes, transitioning into research facilities, and ultimately zooming down to the non-visible microscopic scale using optical and scanning electron microscopy. Throughout the short documentary, scientists are portrayed as active agents, and basic research is framed as a crucial milestone for resolving contemporary societal challenges. This structure bridges academic knowledge with public valuation across economic dimensions (potential industrial uses of mineral resources) and socio-environmental dimensions (coastal erosion and conservation).

To maximize public engagement and accessibility, the text and dialogue were designed around three core strategies:

1: Didactic transposition: translating rigorous geological and mineralogical processes into accessible concepts without sacrificing scientific accuracy.

2: Cultural analogies: using familiar cultural practices such as comparing gravimetric separation to gold panning in order to anchor abstract concepts into the existing cognitive structure of the audience.

3: Dual discourse: blending an omniscient voiceover supported by on-screen text to guide hypotheses and global contexts with authentic, *in-situ* expert interviews to validate methodologies and make science tangible.

2.2 Production phases and scale progression

The production of the short documentary was systematically organized into four operational phases:

Phase 1: Epistemic curation and geographical delimitation. Academic literature was curated to select target scientific terminology regarding heavy minerals, electromagnetic separation, panning, binocular and electron microscopy and other laboratory workflows. Geographically, sample collection sites were delimited to the coastal areas of the Rocha and Maldonado Departments of Uruguay. Laboratory workflows and researcher interviews were recorded at the research facilities of the Departamento de Geociencias, Centro Universitario Regional Este, Universidad de la República, Uruguay.

Phase 2: Narrative sequencing and scale progression. The technical content was sectioned into continuous pedagogical units structured across four spatial scales: Macroscale: visualizing landscapes, beaches and macroscopic sediment transport dynamics. Mesoscale: explaining the technical and instrumental methodologies behind mineral separation techniques. Microscale: describing specific micro-analytical activities and characterizations. Global scale: zooming out to connect all prior observations with global socio-economic, natural resources and environmental concerns.

Phase 3: Didactic transposition and empirical contrast. Real-time visual materials were developed to convert abstract concepts into simplified, yet precise data. Qualitative empirical tests helped to translate abstract concepts into non-experts vocabulary.

Phase 4: Discourse harmonization and vocabulary review. The off-voice script and the discourses of the expert researchers were revised to minimize non-expert vocabulary and avoid oversaturation of geological literacy. This process balanced cognitive demands while ensuring scientific validation and engagement.



The methodological framework for the short documentary integrates academic content with educational narrative strategies and resulted in a systematic content featured in Table 1.

125

Chapter	Concept	Objective	Strategy
1- Prologue	Colors of coastal sediments	Hook the audience and challenge preconceptions about sand	Sensory description of beaches contrasted with color variations
2- Sand composition	Sedimentary processes and transport dynamics	Explaining weathering, mineral resistance	Longitudinal mapping to illustrate the concept of mineral survival
3- Uruguayan coastline	Regional contextualization and environmental value	Localization and the concept of black sands	Framing the research relevance of Rocha and Maldonado Departments
4- Black sands	Field sampling	Laboratory protocols and sampling tracking	Transition to research facilities, showing sample handling
5- Panning	Gravimetric separation using water	The simplicity of density separation	Protocol for laboratory water panning
6- Heavy minerals	Quantitative threshold of dense vs. light minerals	Define physical boundary through an empirical test	Real-time scale proof comparing mass and volume of magnetite and quartz
7- Frantz electromagnetic separator	Magnetic susceptibility of minerals	Demonstrate electromagnetic separation protocols	Step-by-step electromagnetic adjustment for complete sample separation
8- A hidden universe	Optical description and scanning electron microscopy	Introducing microanalysis via SEM-EDS	Transition from optical colored mineral images to high-magnification SEM-EDS
9- Economic importance	Applied mineralogy and industrial resources	Connecting science with economic value and mineral uses	Case studies of specific minerals such as ilmenite as a source of Ti
10- Coastal retreat	Environmental and anthropogenic impact	Shift focus toward sustainable environmental management	Linking mineral knowledge to solving the coastal erosion crisis
11- Epilogue	Synthesis of natural dynamics	Consolidate the core message	Thematic closing summarizing the connections between geology, economy and environment

Table 1: narrative and pedagogical matrix of the short-documentary.



2.3 Multi-channel social dissemination strategy

To reach a broad, non-expert audience, a multi-channel dissemination strategy combining digital platforms and
130 synchronous face-to-face scientific events was deployed.

The short documentary was published as an open-access resource on the video-sharing platform YouTube
(<https://www.youtube.com/watch?v=KxPq49W8fh0>). To foster community dialogue, the project was integrated into the
specialized social media ecosystem of the co-authors, including the Instagram account *@mategeologico* and the web
repository “Un espacio para las Geociencias en diálogo con una comunidad entusiasta”
135 (<https://unespacioparalageociencias.mozello.com/>). Microcontents and direct links were additionally circulated through
professional (e.g. *@mnhn_uy*, <https://ceibal.webex.com/meet/vc24>) and personal Whatsapp and other social media.

To capture audiences outside the digital ecosystem, the short documentary was integrated into in-person science
communication events. Face-to-face events where the video was reproduced were intended not only to share the short-
documentary content, but also as a way to promote it for the casual general audience to become aware of it as recommended
140 by Maynard (2021).

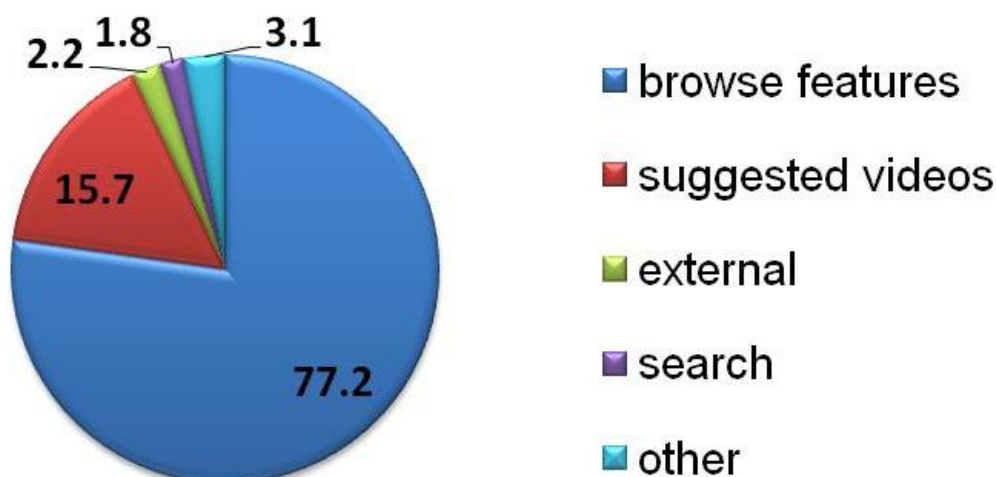
3. Results

The short-documentary (17-minutes) was produced in 2024 and it was officially launched on December 6, 2024.
Over a 566-days continuous tracking window, as of June 6, 2026, the multimedia asset achieved a milestone of 35,704 views
and 3124 cumulative playback hours. This represents 2800 hours above the standard performance average for educational
145 content of similar length, according to the platform analytical baseline.

Analysis of traffic distribution shows that viewership was predominantly driven by Browse Features, which
accounted for 77.2% of total views, followed by Suggested Videos at 15.7%; External links and direct platform searches
represented approximately 2% each (Fig. 1).

Audience retention metrics demonstrated high sustained attention throughout the 17-minutes duration. During the
150 initial phase of playback, 64% of viewers continued watching after the first 30 seconds. Furthermore, 30% of the audience
maintained engagement past the midpoint of the video, and approximately 20% watched the documentary in its entirety.

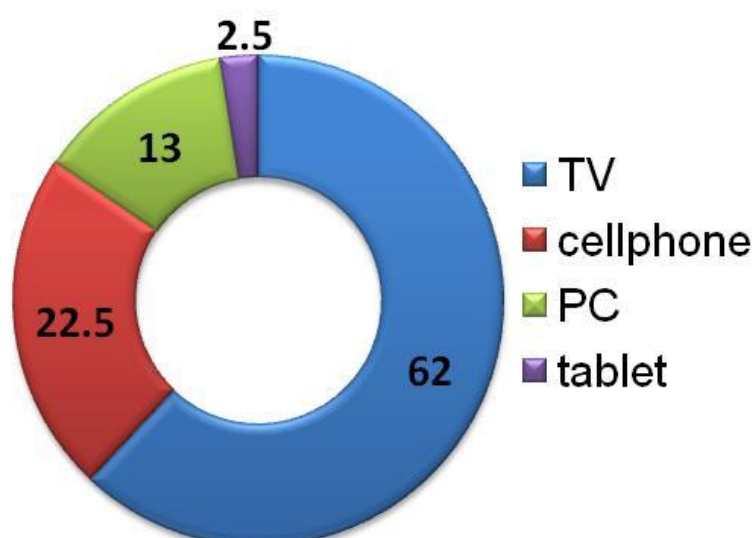
An analysis of playback hardware revealed a distinct domestic viewing pattern. Smart TVs represented the
dominant viewing, capturing 62% of the total, followed by cellphones, computers and tablets in order of abundance (Fig. 2).



155

Figure 1: Distribution of digital traffic sources for the short-documentary on YouTube during 566-day tracking window. The metrics highlight an algorithmic promotion pattern, where Browse Features accounted for 77.2% of the views, followed by Suggested Videos (15.7%), and External/Search Traffic (around 2% each).

160



165

Figure 2: breakdown of audience playback devices for the short-documentary based on YouTube analytics data. Smart TVs represent the dominant viewing platform (62%), followed by mobile devices, personal computers and tablets, indicating a strong preference for living-room consumption over strictly mobile viewing.



The gender distribution of the digital audience was skewed toward male viewers, who accounted for 73.7% of the total, whereas only 26.3% were female viewers. Geographically, the core audience was highly localized within the target region: 69.9 % of viewers are from Uruguay, 12.3% from Argentina and 1.2% from Spain. In terms of age distribution, viewership exhibited a steep progressive increase from younger to older brackets, with the population aged 65 and older representing the dominant consumer group (Fig. 3).

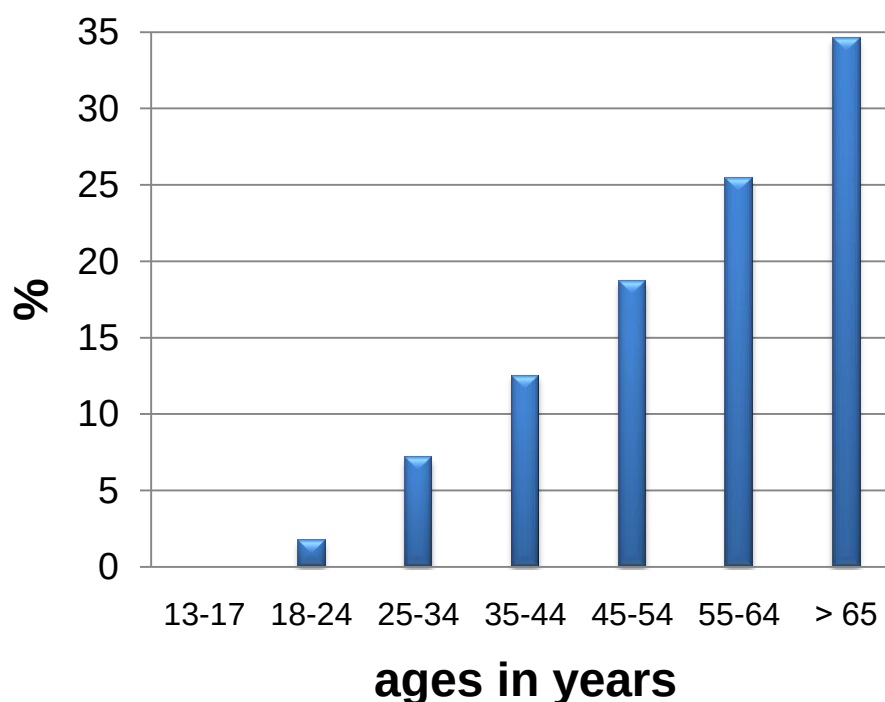


Figure 3: Audience demographics by age group for the digital distribution of the short-documentary. The data demonstrates an exponential increase in viewership from younger toward older populations, with the above 65 years old bracket representing the most dominant consumer group.

A thematic analysis of the open-ended text comments ($n > 100$) received during the initial launch window revealed three critical thematic clusters:

- a) Community validation and knowledge sharing: the majority of responses expressed positive affective reactions, congratulating the researchers. Multiple viewers shared personal observations of other localized coastal sectors in Uruguay where they had previously observed black sand accumulations. Secondary school educators share that they have experience researching black sand alongside their students.



- 185 b) Environmental and socio-economic concerns: a significant cluster of comments revealed anxiety regarding the exploitation of natural resources. Users expressed concern that the data obtained through the research could be co-opted by mining industries, potentially threatening local beach preservation and the coastal tourism economy.
- c) Scientific misconceptions: the analysis uncovered deep-seated misconceptions regarding sediment color. Several users initially associated the black sands with anthropogenic hydrocarbon contamination or potential radioactivity, though knowing that shouldn't pose a problem to human health, but for the environment.
- 190

Several face-to-face events were attended during the time span between the short-documentary release on YouTube and the time of the present publication (Fig. 4), including: i) The Education Fair of the Department of Treinta y Tres, providing direct localized impact near the research facilities and to the communities relatively adjacent to the studied coastal sediments; ii) The National Science and Technology Week, validating the short-documentary as an official instrument for national scientific literacy and institutional outreach; iii) Academic and community workshops, serving as an interactive pedagogical tool to introduce students, educators and general public to geological laboratories and instrumentation.

195

4. Discussion

The primary vehicle for viewer acquisition was driven by YouTube's Browse Features, deviating from traditional high-traffic digital media patterns, where the related-video recommendation system dominates (Zhou et al., 2010). This unexpected algorithmic behavior indicates that the platform actively pushed the documentary onto users' primary home feeds. The algorithm prioritized the video probably because it filled the social demand for localized, high-quality geoscience content. Due to the scarcity of accessible digital resources regarding sedimentary geology in Latin America, the introduction of an epistemically rigorous yet engaging asset triggered high early interaction metrics. The high retention rates and algorithmic push confirm that non-expert audiences possess an inherent interest in understanding the geological processes shaping their immediate territory, provided the communication framework reduces cognitive barriers.

200

205

The finding that Smart TVs represented the dominant viewing platform (62%) challenges contemporary assumptions that digital informal learning is an isolated, strictly mobile-phone centered activity. Instead, this pronounced preference for television-based playback suggests a living-room or communal consumption model, where scientific content is integrated into domestic and shared family spaces.

210

This unique playback dynamic directly aligns with contemporary socio-technological infrastructure in Uruguay. According to the National Survey on Information and Communication Technologies (EUTIC) published by AGESIC (2024), domestic Wi-Fi connectivity and Smart TV penetration have experienced widespread growth across Uruguayan households. The structural availability of stable fiber-optic networks facilitates long-form video consumption (17 minutes) on large screens.

215

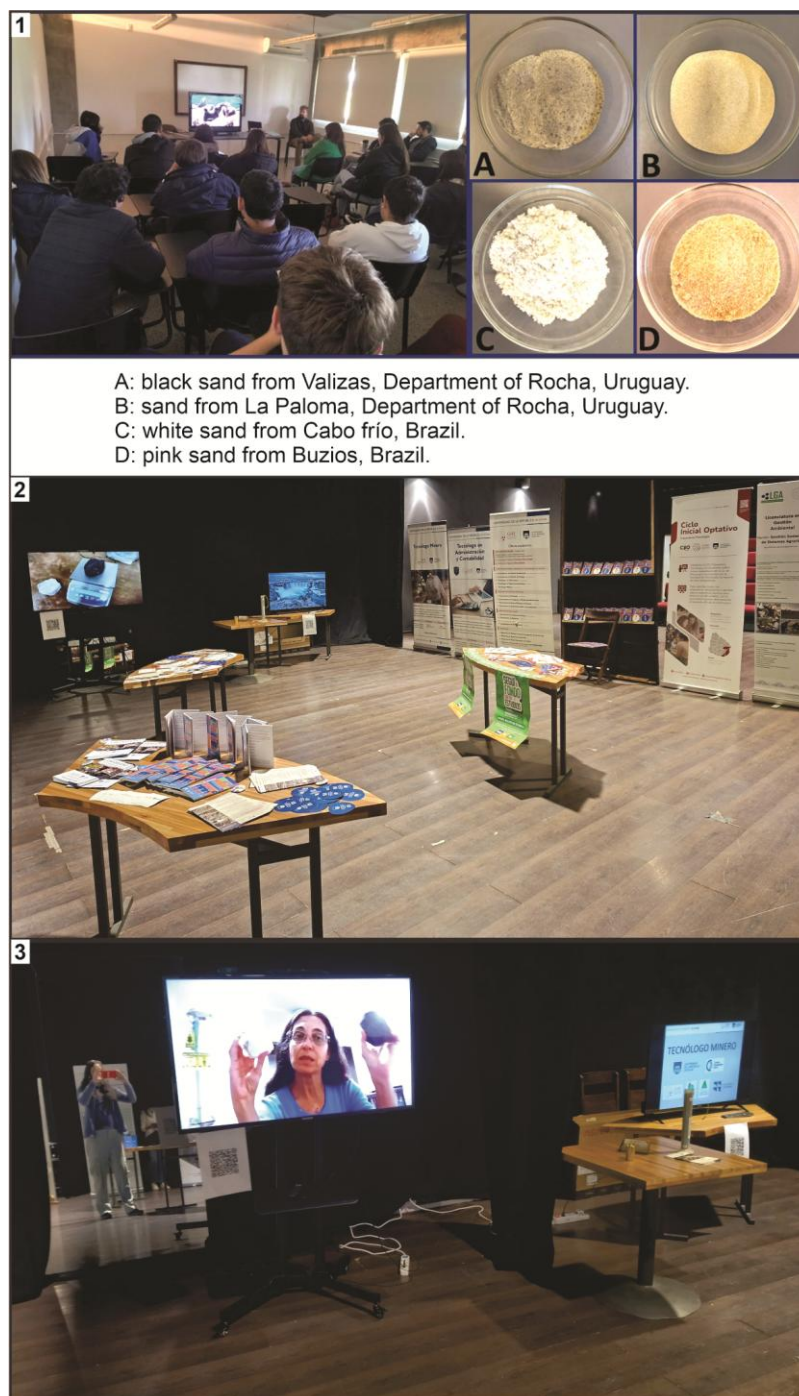


Figure 4: Integration of the short-documentary into institutional face-to-face events in Uruguay. 1) Science and Technology Week, may 2025 at Sede Treinta y Tres of CURE, Uruguay. 2) and 3) Educational Fair of the Department of Treinta y Tres, October 2025, featuring physical interactive stands and QR code to facilitate direct, localized cross-platform social media sharing among students, educators, and the general public.



While digital science communication tools are frequently designed under the assumption that they primarily attract younger generations, our findings demonstrate an inverted age demographic, where the population aged 65 and older was the most dominant consumer group. This demographic profile is highly consistent with the national data showing that over 78% of Uruguayan citizens aged 65 and older are active internet users (AGESIC, 2024). While half of the country's population sits above a median age of 36.2 years (Kemp, 2025), the documentary successfully tapped into this digitally literate and understudied elderly audience. This older demographic is often deeply anchored to their geographic region; thus, their high engagement supports place-based education frameworks (Litrell et al., 2019), which state that spatial familiarity enhances internal motivation to learn. Conversely, the skewed male viewership (73.7%) replicates gender gaps observed in other digital geosciences media (Wang et al., 2022), pointing to the ongoing challenge of designing geosciences communication frameworks that actively attract diverse genders. Capturing younger audiences remains a distinct challenge.

The qualitative analysis of public comments highlighted how immediate negative emotions such as anxiety over potential mining exploitation, radioactivity or hydrocarbon contamination frequently cloud the objective evaluation of natural geological phenomena. In geosciences, public risk perception is highly non-linear and influenced by deep-seated local beliefs and socio-economic fears. To counter the cognitive barriers, the application of structured Didactic Transposition (Lacchia et al., 2020) proved essential. By shifting the script's narrative from abstract parameters down to observable mechanical actions and anchoring scale transitions with cultural analogies, the video successfully deactivated immediate risk biases. Deconstructing perceptual biases first by challenging sensory preconceptions (the "mystery" of sand colors) created a cognitive inconsistency that sustained public attention. This method allowed the non-expert audience to process dense theoretical data safely, bridging the gap between scientific truth and community values through shared regional frameworks.

5. Practical implications and design guidelines

The successful implementation of this place-based scriptwriting workflow offers a scalable framework for both scientific researchers and educators in the geosciences. Based on the production outcomes, algorithm performance and multi-channel audience responses, the following practical guidelines are proposed for future geosciences communication projects.

- a) Deconstruct perceptual biases first. Implication: abstract scientific definitions rarely engage a non-expert audience at first glance. Recommendation: scripts should begin with an everyday sensory experience (e.g. the familiar environment of a beach) and immediately introduce a visible anomaly (e.g. the presence of rare colored sands). Challenging the audience common preconceptions creates a cognitive inconsistency which acts as a powerful hook to sustain attention before introducing dense theoretical information.
- b) Prioritize action oriented explanation over text. Implication: the overuse of technical glossaries isolates the viewer and limits conceptual retention. Recommendation: when filming active laboratory instrumentation, passive descriptions must be minimized; instead, preference should be given to action-driven scenes where researchers speak



fluently in accessible language while actively manipulating samples or equipment, thereby explaining facts through mechanical and observable actions.

- c) Anchor scale transitions with cultural analogies. Implications: microscopic variables and numerical thresholds (such as the 2.9 g/cm^3 density limit) can feel completely abstract and disconnected from reality to the non-expert audience. Recommendation: complex or non-visible scientific processes should always be anchored to a widespread cultural reference. For example, equating gravimetric laboratory separation with historical gold panning provides an immediate and accessible mental model. This allows viewers to visualize and understand advanced geological physics through familiar mechanical concepts.
- d) Design multiscale narratives for hybrid ecosystems. Implications: educational videos should not exist as isolated assets; they must be structurally optimized to seamlessly fit both, physical exhibitions and formal educational curricula. Recommendation: dividing the script into continuous yet independent chapters allows educators to fragment playback during face-to-face events. For instance, chapters 5 through 7 can be utilized specifically to illustrate laboratory techniques, whereas chapters 9 and 10 independently kickstart community debates regarding regional resource management and coastal retreat.
- e) Integrate socio-economic and environmental concerns with affective storytelling. Implication: isolating scientific data from the immediate socio-environmental and emotional realities of the territory can trigger public detachment or provoke cognitive resistance. Recommendation: geosciences communication frameworks must place the human and regional element at the core of the narrative. Blending geological data with affective components through storytelling establishes an authentic and meaningful dialogue. This approach successfully bridges the gap between expert researchers and non-expert audiences by aligning scientific discoveries with shared regional identity, territory-based values, and environmental conservation goals.

6. Conclusion

The development and multi-channel dissemination of the short-documentary “Arena negra, un misterio oculto en las playas de Uruguay” demonstrates the high efficacy of place-based audiovisual storytelling in bypassing the barriers of traditional academic isolation. By shifting the narrative focus from abstract theoretical explanations to observable actions within the laboratories, the script successfully bridged the gap between complex academic research and public accessibility without sacrificing epistemic rigor. The integration of balanced verbal and visual instructional multimedia, paired with the transparency of showcasing real researchers navigating authentic research workflows, served as a primary catalyst for maximizing public engagement and fostering a strong emotional connection with a non-expert audience.

Structuring the scientific script across distinct, hierarchical working scales, progressing dynamically from macroscopic coastal landscapes down to laboratory, microscales and back to global socio-environmental concerns, significantly optimized the audience’s cognitive retention. Ending the audiovisual narrative with concrete applications in



285 applied mineralogy and contemporary environmental crises, such as coastal retreat and anthropogenic erosion, successfully shifted the public perception of basic geosciences. Rather than being viewed as an isolated academic exercise, the discipline was repositioned as an essential, high-utility tool for sustainable regional development and civic environmental decision making.

Furthermore, this intervention established a highly cost-effective and flexible informal learning resource. The open-
290 access nature of the digital platform, coupled with its high domestic consumption on Smart TVs, empowered citizens with localized spatial contingency to engage with autonomous scientific literacy at their own pace, time and frequency, effectively addressing the structural scarcity of formal science communication centers and museums in the interior regions of the country. Crucially, the study revealed an understudied digitally literate elderly demographic that is highly receptive to regional Earth Science content when cognitive demands are minimized.

295 Ultimately, this study provides a scalable and replicable framework for geoscientists, academic institutions, and science communicators aiming to translate rigorous laboratory protocols into dynamic, problem-solving narratives capable of fostering regional environmental awareness. Future research should evaluate the adaptability of this placed-based framework across broader geographical domains, examining the extent to which international audience engagement scales through English dubbing, localization strategies and the implementation of multilingual subtitles.

300 **Author contributions**

P. Abre: conceptualization, methodology, investigation, data curation, writing - original draft and editing and, Project administration. Lugo, F.: conceptualization, methodology, investigation and writing – review and editing. Blanco, G.: investigation, visualization and writing – review and editing. are required to add a section in which the contributions of all co-authors are briefly described.

305 **Competing interests**

The authors declare that they have no conflict of interest.

Ethical statement

The authors declare that this study was conducted in strict accordance with international ethical standards for digital research and public data analysis. The quantitative audience metrics and demographic insights presented in this study were
310 aggregated and completely anonymized by the hosting platform (YouTube/Google Analytics) prior to access; no personally identifiable information (PII) was collected, tracked, or stored by the researchers. Furthermore, the qualitative analysis of public user comments was restricted exclusively to text published voluntarily in the public domain. To ensure complete



315 privacy and prevent tracking, all analyzed comments have been fully anonymized in the text, and usernames or digital handles have been strictly omitted. No formal institutional review board (IRB) approval was required as the study relied entirely on pre-existing, aggregated, and publicly available non-sensitive data, posing zero risk to participants.

Disclaimer

320 Copernicus Publications remains neutral with regard to jurisdictional claims made in the text, published maps, institutional affiliations, or any other geographical representation in this paper. While Copernicus Publications makes every effort to include appropriate place names, the final responsibility lies with the authors. Views expressed in the text are those of the authors and do not necessarily reflect the views of the publisher.

Code/Data availability

All relevant data supporting the findings of this study are fully contained within the manuscript, primarily through its figures and tables. The original 17-minute documentary film "Arena negra, un misterio oculto en las playas de Uruguay" can be accessed freely on YouTube.

325 Acknowledgements

We are grateful to the Departamento de Geociencias of Centro Universitario Regional Este, Universidad de la República, Uruguay, for providing institutional support. Special thanks are extended to Camila Zunino for her valuable assistance during the filming of certain laboratory scenes.

References

- 330 Agencia de Gobierno Electrónico y Sociedad de la Información y del Conocimiento (AGESIC): Informe EUTIC 2024. <https://www.gub.uy/agencia-gobierno-electronico-sociedad-informacion-conocimiento/tematica/eutic>, 2024
- Beautemps, J., and Bresges, A.: What Comprises a Successful Educational Science YouTube Video? A Five-Thousand User Survey on Viewing Behaviors and Self-Perceived Importance of Various Variables Controlled by Content Creators. *Front. Commun.* 5:600595. doi: 10.3389/fcomm.2020.600595, 2021
- 335 Bergillos Ruíz, P.: Aplicaciones del medio video en el aprendizaje de la geología. *Enseñanzas de la Tierra* 1 (1): 44-46. <https://raco.cat/index.php/ECT/article/view/88083>, 1993
- Boy, B., Bucher, H-J, and Christ, K.: Audiovisual Science Communication on TV and YouTube. How Recipients Understand and Evaluate Science Videos. *Front. Commun.* 5:608620. doi: 10.3389/fcomm.2020.608620, 2020



- Brusi, D., and Calonge, A.: La geología es importante. Pongámosla en valor. *Enseñanza de las Ciencias de la Tierra*, 31 (2):
340 191-195. <https://raco.cat/index.php/ECT/article/view/980000008476>, 2025
- Delgado Iglesias, J., and Calonge García, M. A.: Estudio de la presencia de la Geología en currículos oficiales autonómicos
de Educación Primaria. *Enseñanza de las Ciencias de la Tierra*, 26 (2), 154-162.
<https://raco.cat/index.php/ECT/article/view/338581/429533>, 2018
- Kemp, S.: Digital 2025: Uruguay. <https://datareportal.com/reports/digital-2025-uruguay>, 2025
- 345 Lacchia, A., Schuitema, G., and McAuliffe, F.: The human side of geoscientists: comparing geoscientists' and non-
geoscientists' cognitive and affective responses to geology. *Geoscience Communication*, 3, 291–302,
<https://doi.org/10.5194/gc-3-291-2020>, 2020
- Littrell, M. K., Okochi, C., Gold, A. U., Leckey, E., Tayne, K., Lynds, S., Williams, V., and Wise, S.: Exploring students'
engagement with place based environmental challenges through filmmaking: A case study from the Lens on Climate Change
350 program, *Journal of Geoscience Education*, DOI: 10.1080/10899995.2019.1633510, 2019
- Martínez Bracerías, N., Bodego, A., Payros, A., and Antón, A.: Análisis de la enseñanza de los procesos geológicos externos
en la educación secundaria obligatoria del País Vasco. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias*, 19(2),
2102. doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2022.v19.i2.2102, 2022
- Maynard, A. D.: How to Succeed as an Academic on YouTube. *Front. Commun.* 5:572181. doi:
355 10.3389/fcomm.2020.572181, 2021
- Mingo Zapatero, B., and García Guinea, J.: Geología en el Campo: una experiencia sobre vídeos educativos en Geociencias.
Estudios Geológicos, 81(2). doi.org/10.3989/egeol.45705.1129, 2025
- Nisbet, M. C., Hixon, M. A., Moore, K. D., and Nelson, M.: Four cultures: New synergies for engaging society on climate
change, *Frontiers in Ecology and the Environment*, 8, 329–331. <https://doi.org/10.1890/1540-9295-8.6.329>, 2010
- 360 Pavelle, S., and Wilkinson, C.: Into the Digital Wild: Utilizing Twitter, Instagram, YouTube, and Facebook for Effective
Science and Environmental Communication. *Front. Commun.* 5:575122. doi: 10.3389/fcomm.2020.575122, 2020
- Rahmatika, R., Yusuf, M., and Agung, L.: The Effectiveness of Youtube as an Online Learning Media. *Journal of Education
Technology*, 5(1), 152–158. <https://doi.org/10.23887/jet.v5i1.33628>, 2021
- Rooney-Varga, J. N., Allende Brisk, A., Adams, E., Shuldman, M., and Rath, K.: Student Media Production to Meet
365 Challenges in Climate Change Science Education, *Journal of Geoscience Education*, 62:4, 598-608, DOI: 10.5408/13-050.1,
2014
- Sancho Úbeda, J.: Los documentales científicos como instrumentos de formación ciudadana para hacer frente a la situación
de emergencia planetaria. *Enseñanza de las Ciencias*, Número Extra VIII Congreso Internacional sobre Investigación en
Didáctica de las Ciencias, Barcelona, pp. 113-116. <https://raco.cat/index.php/Ensenanza/article/view/293428>, 2009
- 370 Schanner, M. A., Nielsen, K., Bickerton, P., Panovska, S., and Kervalishvili, G.: An audiovisual representation of a
geomagnetic excursion for public engagement. *Frontiers Earth Sciences*, 13:1727273. doi: 10.3389/feart.2025.1727273,
2026



- Velho, R. M., and Barata, G.: Profiles, Challenges, and Motivations of Science YouTubers. *Front. Commun.* 5:542936. doi: 10.3389/fcomm.2020.542936, 2020
- 375 Wang, N., Clowdus, Z., Sealander, A., and Stern, R.: Geonews: timely geoscience educational YouTube videos about recent geologic events, *Geoscience Communication*, 5, 125–142, <https://doi.org/10.5194/gc-5-125-2022>, 2022
- Zhou, R., Khemmarat, S., and Gao, L.: The impact of YouTube recommendation system on video views. In *Proceedings of the 10th ACM SIGCOMM conference on Internet measurement (IMC '10)*. Association for Computing Machinery, New York, NY, USA, 404–410. <https://doi.org/10.1145/1879141.1879193>, 2010