ISSN 2529-9824

Artículo de Investigación

Science communication for a sustainable academia: a comparative analysis of public and private universities Netherlands, Portugal, and Spain

La comunicación de la ciencia por una academia sostenible: estudio comparativo de las universidades públicas y privadas de Países Bajos, Portugal y España

Rocio Torres-Mancera[1]: University of Malaga, Spain.
rociotorres@uma.es
Estrella Martínez-Rodrigo: University of Granada, Spain.
emrodrigo@ugr.es

Fecha de Recepción: 15/06/2024

Fecha de Aceptación: 05/10/2024

Fecha de Publicación: 12/11/2024

How to cite the article:

Torres-Mancera, R., & Martínez-Rodrigo, E. (2024). Science communication for a sustainable academia: a comparative analysis of public and private universities Netherlands, Portugal, and Spain [La comunicación de la ciencia por una academia sostenible: estudio comparativo de las universidades públicas y privadas de Países Bajos, Portugal y España]. *European Public & Social Innovation Review*, 9, 1-21. https://doi.org/10.31637/epsir-2024-1392

Abstract:
Introduction: This research outlines a comprehensive study aimed at exploring the role of science communication in high education institutions, its impact and future sustainability in European universities across Netherlands, Portugal, and Spain. **Methodology**: By conducting a comparative review, we aim to provide valuable insights that can inform policy decisions and practices in the field of education sciences sharing knowledge in a more efficient manner. Through an examination of existing corporate data of public and private centers (N = 166) by conducting an exhaustive quantitative and correlational analysis of its official digital communications. **Results:** it is spotted that Spanish universities include more direct messages

[1] **Corresponding author:** Rocio Torres-Mancera**.** University of Malaga (Spain).

towards science communications, while Netherlands make much less general load but focuses more on sustainability topics. Findings suggests that in the stakeholder management, quantitative attempts in digital media are stronger from public institutions but may not be as decisive as the quality efforts, given that although Spain leads a higher gross value of online corporate communications, Dutch and Portuguese public universities are relatively much better valued in the global worldwide academic classification. **Conclusions**: This first study reveals an innovative unique new approach in cross-analyzing sustainable scientist knowledge, European universities, and international rating impacts based on the ARWU ranking.

Keywords: science for all; education sciences; impact; sustainability; strategies; cross-cultural analysis; knowledge dissemination, stakeholder´s management.

Resumen:
Introducción: Un estudio exhaustivo destinado a explorar el papel de la comunicación científica, su impacto y su sostenibilidad futura en las universidades europeas de los Países Bajos, Portugal y España. **Metodología**: Mediante una revisión comparativa de las prácticas actuales para compartir conocimiento comunicando a través de sus en soportes digitales oficiales, y a través del análisis cuantitativo y correlacional de datos corporativos de 166 universidades públicas y privadas. **Resultados:** Los resultados sugieren que en la gestión de los grupos de interés, los intentos cuantitativos en medios digitales son más fuertes por parte de las instituciones públicas, pero pueden no ser tan decisivos como los esfuerzos de calidad, dado que aunque España lidera un mayor valor bruto de las comunicaciones corporativas online, las universidades públicas holandesas y portuguesas están relativamente mucho mejor valoradas en la clasificación académica mundial global. **Discusión**: Las universidades españolas tienden a incluir mensajes más directos relacionados con la comunicación científica, mientras que las universidades holandesas, aunque tienen una carga comunicativa general menor, se centran más en temas de sostenibilidad. **Conclusiones**: El estudio revela un enfoque innovador cruzado de los conocimientos científicos sostenibles, las universidades europeas y los impactos de la clasificación internacional basada en la clasificación ARWU.

Palabras clave: ciencia para todos, educación, impacto, sostenibilidad, estrategia, análisis intercultural, transferencia de conocimiento, gestión de grupos de interés.

1. Introduction

In recent years, the concept and practice of science communication seem to be gaining interest in universities, underscoring its transformative potential. An effective communication of scientific knowledge from Academia (Bennett et al., 2023; Besley et al., 2020) could leverage the learning experience facilitating a broader dissemination of relevant innovative research outputs to stakeholders (Grunig, 2023; Thorp, 2020) extending the boundaries of knowledge echoes, community engagement, societal impact, and a sustainable local development (Alzubi, 2018; Davies, 2021; Mahdi et al., 2019).

Training scientists and universities for effective communication (Fähnrich, 2021) with stakeholders, including non-professional audiences, remains challenging due to ongoing debates on defining and measuring such messages (Capers et al., 2022; Chinn & Duncan, 2018) for reputational purposes (Anderson et al., 2012; Hmielowski et al., 2014; Miotto et al., 2020).This study is built up with the purpose to bring to light the state of science communication (SC) practices in public and private universities, through the analysis of three European countries: Netherlands, Portugal, and Spain. The exploration seeks not only to identify divergent and convergent current data, but also to inspire and inform innovative

advancements in science communication within higher education institutions, to improve their curricula, their expected impact on society, and recognition from renowned international ranks such as the Academic Ranking of World Universities (ARWU).

In line with these objectives, research questions are drawn up to enable the data collection to be conducted swiftly in order to provide answers to the study in progress.

- RQ1: Is science communication promoted more in European public or private universities?
- RQ2: Are there differences in raising awareness and disseminating messages related to the value of sustainability according to the type of university and origin?
- RQ3: Do internationally ranked universities communicate their research results more effectively in order to promote knowledge transfer?

1.1. Research impact values

Academia and researchers are facing growing demands to convey their scientist findings to all stakeholders including the general community, media, governments policymakers, and specialists beyond their own disciplines (Thorp, 2020). In this regard, while science communication educational initiatives aspire to enhance scientists' ability to engage with the public about their research, existing research highlights a limitation in their strategic orientation, often emphasizing a few skills rather than a comprehensive approach. In this respect, results from recent study conducted by Bennett et al. (2023), shows that a significant majority of scientists actively engage in public outreach, emphasizing various science communication objectives such as influencing policy influencers with solid evidence, enabling autonomous decision-making at the individual level, and fostering societal appreciation for science (Besley, 2020).

The communication of science and technology is a current key concern for public and private educative institutions. Over recent decades, this field has grown significantly, leading to intense social and political discussions on issues like the reliability of information, trust in science, and how experts play a role in times of crises and emergencies (Bucchi & Trench 2021). in the same period, it is being recognized the important of SC practices for society supported by private and public fundings to ensure financial sustainability within organizations, enhance cultural significance, share knowledge, and contribute to economic growth (Davies, 2021).

Concerning academic research methodologies, a noticeable gap exists in studies that prioritize action research as a central focus (Martins et al., 2019). Two decades ago, rankings were uncommon in Europe, but the 'Bologna process' initiated standardization efforts across European higher education. Since then, European universities use rankings to shape perceptions and influence their positions, inadvertently reinforcing existing status dynamics (Wedlin, 2011) measuring different criteria under the ponderation of Employability (55%), Research (20%), Program Features (16%), and School Features (9%).

These international rankings seem to be making a high pressure to universities and business schools to conform, limiting diversity and innovation, especially for smaller or unaccredited institutions, establishing an “iron cage” that shapes the content, excellence, and teaching methods of the curriculum (Lozano et al., 2020). This way, while appearing beneficial, many top-ranked schools incur high costs and fosters a follower's approach to conquer the crucial differentiation that many small or unranked universities may be willing to emulate.

Training scientists and universities for better communication with non-professional audiences seem crucial, but there's ongoing debate and challenge on defining and measuring "effective communication" (Capers et al., 2022) behaviors. Numerous experts in psychology, education, and philosophy consider that the value of scientist knowledge is intricately linked to their specific disciplines, reasoning, and argumentative skills to share when communicating scientific concepts (Chinn & Duncan, 2018) to the world. Particularly, average common adults with a general understanding of scientific reasoning may not possess the ability to directly assess evidence or determine which experts to trust, particularly towards studies that causes controversial debates and disputes. Previously, research conducted by Entradas and Bauer (2016) founded differences in public engagement practices between scientific disciplines, with Social Sciences expected to excel at the institutional level, contributing more to civic engagement, while Natural Sciences prioritize educational activities, influenced by factors like the size of the university, fundings, and management preferences.

But understanding basic scientific reasoning helps build trust in their methods, understand academic issues, dialogue with specialists, and promote cooperative proactivity. Depending on the environment where it needs to be applied, effective SC requires key competences to be performed to assure successful actions. To this purpose, tailored clear objectives to educate the community is crucial, encompassing communicational skills and supports (Lewenstein & Baram-Tsabari, 2022).

Regarding ethics and values in educational sciences, Seethaler et al. (2019) argue that the prevalent paradigm is centered on knowledge transmission, showing resistance to transformation, underscoring the constrained impact of SC research on practical applications. People studying and working in SC could pay attention to trust, competence, integrity, benevolence, and openness (Besley et al, 2021) training their capabilities to know that how they are perceived and how to behave to transfer knowledge in an ever changing world. In achieving the perception of honesty and reputation within the new digital era, universities and their research teams should begin by showcasing integrity and then explore methods to disseminate information that fosters such beliefs (Besley et al, 2021). Aligning with a fundamental principle of public relations, effective relationship building involves not only communication but also adjusting communicative behavior in a way that addresses the concerns and needs of stakeholders (Grunig, 2023).

In a highly competitive landscape, public universities need to embrace a proactive management strategy, leveraging intangible assets such as reputation and legitimacy to achieve positive distinctiveness, while also examining the influence of reputation on brand image and credibility in the higher education sector (Miotto et al., 2020) In fact, the study conducted in Spain by these authors emphasized that public universities strive to attract candidates globally and are impacted by international rankings evaluating academic performance, student experience, employability results, and the transfer of knowledge to the business sector.

1.2. Digital Science Communication

The evolution of digital communication platforms poses both opportunities and challenges for SC, demanding new forms of preparation and support for science communicators—comprising scientists, researchers, journalists, and diverse content creators—to effectively engage diverse audiences across various channels. However, despite the growing demand for adequate training, the field lacks comprehensive research, often relying on isolated case studies, highlighting the need for a broader understanding of the essential competences required to navigate the evolving science communication landscape (Fähnrich et al., 2021)

These facts implies that science communication is facing the impacts of globalization and digitalization, requiring proficient communicators to meet the changing demands of society.

New modes of SC are defined by their dynamic nature and speed, enabling citizens to actively participate in an environment marked by novel structures of knowledge (Neuberger et al., 2019). This paradigm would offer benefits for those universities who bet for new platforms to share information and more adaptable messages. Yet science communicators must be mindful of risks, such as the potential misuse of science related information and the misinformation, like it happened during the COVID-19.

Reconfiguring ongoing initiatives, citizen science conceptualization highlights serving as a conduit, fostering a connection between science and society by actively inviting diverse opinions, values, perspectives, experiences, and individualities without losing their distinctiveness (Judd & McKinnon, 2021). By doing so, citizen science could encompass various objectives like research, education, stakeholders' management, and strengthening communicational skills to embrace inclusive practices. Thus, inclusive participation in citizen science projects, defined as instances where the public voluntarily assists in scientific research, can only be achieved through proactive measures (Haklay et al., 2021)

Outlining the essential practical skills needed for communicators to engage in SC with assurance, Lewenstein and Baram-Tsabari (2022) acknowledge the range of individuals involved in communication and the diverse targets they aim to address depending on 3 communicative styles: occasional, engaged, and expert. Recent studies also indicate that representations of scientists in the media tend to be favorable, and while not a direct correlation, audience perceptions of scientists can be influenced by engagement with mainstream media (Dudo et al., 2011; Besley et al., 2020).

Trust in institutional sources seem to be shaped by the media's heavy reliance on elite figures, with public affairs media influencing believes towards scientists and governmental bodies; bringing to light the absence of public relations professionals as sources in this type of communication (Anderson et al., 2012). Hmielowski et al. (2014) explored the importance of trust in scientists acts as a mediator, shaping the influence of news media on perceptions of common problems such as the global warming. Their results demonstrated that conservative media decreased trust and certainty, while non conservative media seem to increase trust and certainty. Similarly, it appears that non-experts rely on expert guidance to assess scientific information, judging reliability through expertise, commitment to scientific norms, and positive motivations.

1.3. Sustainable Knowledge Transference

Even if temporary SC projects provide a testing ground for inclusive practices, they have limited reach and impact in driving systemic sustainable change (Dawson, 2014). Understanding the drivers influencing knowledge transfer (KT) is crucial, as wisdom serves as a fundamental resource for sustainability and competitive advantage (Alzubi, 2018).

Effectively reaching stakeholders, correcting misinformation, promoting broader involvement an inclusive practice in science become fundamental aspects of SC practice (Fecher et al., 2021), according to the primary research focus on knowledge dissemination. But sharing uncertainties is a very common complex process, and the effects vary due to factors like pre-existing opinions and motivated reasoning (Gustafson & Rice, 2020).

The utilization of knowledge management in the sustainability context has become increasingly crucial, yet this area remains underexplored (Martins et al., 2019), presenting abundant opportunities for university based research. This would mean that opportunities lie in harnessing universities as knowledge generation hubs and integrating knowledge management to establish guidelines for productive systems, employing diverse research approaches to develop targeted models and tools for information sharing.

The competitive edge of universities and companies is now intricately linked to the significance of knowledge and its dissemination. I.e., Teixeira et al. (2019) carried on a case of study in Portugal, it put in evidence that cooperation between younger entrepreneurs and urban based companies, especially in Lisbon, fosters KT, drived innovation and socio-economic impact; however, the influence of public universities on competitiveness and the effects of enduring entrepreneurial collaboration merit additional investigation. Simultaneously, recent research focused on private educational institutions and KT for a sustained challenging advantage, highlights information as a critical asset that requires efficient leadership to bolster the competitive capabilities of organizations, contributing to its long-term sustainability (Mahdi et al., 2019). In the meantime, globalization, rankings, and limited public funding intensify competition for public universities, where intangible factors like reputation and credibility are crucial for long-term advantage among rising expectations in research, teaching, and community engagement (Miotto et al., 2020).

2. Methodology

The research involves a mixed-method approach for data collection, based on a three-step pathway to support efficiently findings dissection:

I) A literature review of most recent outstanding studies regarding SC, knowledge transfer from academia to stakeholders and sustainability from universities for society and environment. To this purpose current most cited articles are reviewed, if they comply with the main premise of having been published in international journals of recognized high impact.

II) A quantitative content analysis of SC digital messages produced in open access by universities to general society trough their official corporate webpages. For this quantification of data, the technique of content analysis is applied to generate objective, relevant, homogeneous, and systematized information (De Sola & Berelson, 1952; Stemler, 2001; Riffe et al., 2019). from the official communications of the higher education organizations selected for the sample, in their digital formats.

The European sample comprises the whole universe of universities -public and private- from the 3 countries selected for this first approach research: Netherlands, Portugal, and Spain (see table 1).

Table 1.

Methodological design

Research design	Key contents	Time frame	Documentary support
Study: Science Communication for sustainability with stakeholders Target: European cases Countries: Netherlands, Portugal, and Spain Sample: All public and private universities	"scien*" "(communicat*" "science + comunicat*" "knowledge transfer" "sustainab*" "output*" "research" "impact*" "discover*" + name of each university	2023	▸ Official websites ▸ ARWU 2023

Source: Own elaboration (2024).

III) A comparative analysis of data collected comparing convergences and divergences of the total amount of higher education centers of the three countries regarding science communication volume of diffusion practices and their impact on education sciences reputation. With this purpose, a correlational analysis of universities listed in year 2023 by the Academic Ranking of World Universities (ARWU) – also known as the Shanghai official ranking-, to gain a deeper understanding of correspondence between communicative strategies and successful impact on qualitative and quantitative standards for the top educational organizations.

To facilitate the research a pool of key concepts directly connected to SC for sustainability in higher education are chosen and detailed below. Criteria for this selection is based on direct connection between concepts according to the literature review. The commands to search for official communications made by all the universities in the total sample of the 3 selected European countries, are focused on:

(*scien* + name of university); (communicat* + name of university); (science + comunicat* + name of university) + (knowledge transfer + name of university); (sustainab* + name of university); (output* + name of university); (research + name of university); (impact* + name of university) and (discover*+ name of university*).

In every search string mentioned above, the asterisk functions as a wildcard, encompassing all conceivable variations of a word in the googling activity. For example, scien* would return results containing the words science, scientific, scientist.

IV) Finally, statistical inference is made by applying a correlational analysis to infer the extent to which two key variables in the study are linearly related: a) the digital institutional communication of the European universities, and b) the relevance of their activity in terms of international impact and valuation. Although correlations

do not necessarily imply causality (Babones, 2016) the process includes the act of studying, in a synthesized manner, the convergences and divergences in the volume of digital science communication by university and country, and the position they occupy in the ARWU 2023.

2.1. University sample

The Netherlands has a total population of 18 million people and an area of 92.152 km2, (Statistics Netherlands, 2023) resulting in a population density of 113,59 inhabitants/km2 in 342 municipalities. This Central European country has 344.627 students registered in higher education institutions in 2022, a ratio of young people between 18 and 29 years of age of 16%, (Eurostat, 2023), in contrast to the data from Portugal (16%) and Spain (15%). The country boasts a tertiary attainment rate of 56% among individuals aged 25-34, surpassing the EU average of 41%, accompanied by high graduate employment rates (European Commission, 2022).

In the case of Spain, a country with 48 million inhabitants and an area of 504.645 km2, and a population density of 95.23 inhabitants/km2, (Eurostat, 2023; Instituto Geográfico Nacional, 2023), it has 8,131 municipalities, of which 177 have higher education centers and a net enrolment rate in these organizations of 32% of the total population between 18 and 24 years of age. According to the recently published report of the Spanish University System (Gobierno de España, 2023) in the last academic year there were a total of 1.690.947 students, with a distribution of 79% in Bachelor degrees, 15% in Master degrees and 6% in Doctorate degrees, and a total of 3.112 Bachelor degrees, 3.735 Master degrees and 1.185 Doctorate degrees. In 2021, this country achieved a tertiary education attainment of 49%, surpassing both the EU average of 41% and the EU-level target of 45%, marking a 1,3% increase from 2020 (European Commission, 2022).

Portugal presents a geography with 92.152km2 and a total population close to 10,5M inhabitants, meaning an average density of 113.59 inhabitants/km2 distributed over a total of 308 municipalities (Eurostat, 2023).According to the European Commission (European Commission, 2022), the nation has experienced a rise in the percentage of individuals attaining tertiary education, particularly in the field of ICT. The tertiary education attainment rate among those aged 25-34, increased by 5,6 percentage points in 2021 compared to 2020, surpassing both the EU average (48% compared to 41%) and the EU-level target (45%).

3. Data analysis

3.1. Content analysis per countries

In absolute terms, a total of 166 higher education institutions composes the total sample in accordance with the established criteria of being officially recognized as universities in their countries of origin. In the private sector, there are 41 registered institutions in Spain, 7 in Portugal and 14 in the Netherlands. Regarding training institutions led by the national public administration, there are 50 Spanish, 13 Portuguese and 41 Dutch (see table 2).

Table 2.

Total European samples obtained for the study

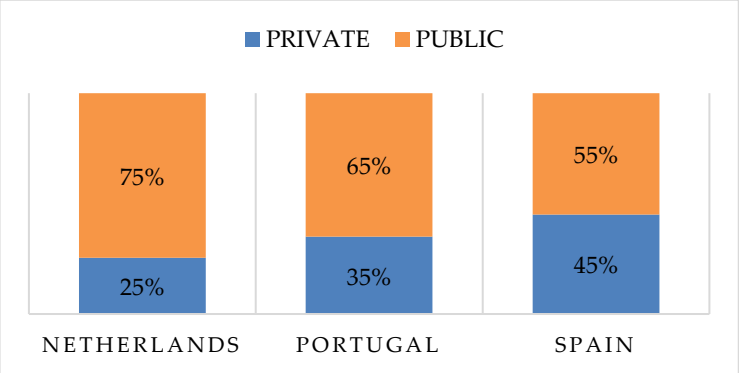
UNIVERSITIES	PRIVATE	PUBLIC	TOTAL
NETHERLANDS	14	41	55
PORTUGAL	7	13	20
SPAIN	41	50	91

Source: Own elaboration (2024).

According to the nature of the main fundings and the management style of the higher education institutions (see figure 1) , public universities account for 75% in the Netherlands, 65% in the case of Portugal and 55% of the Spanish sample; while private institutions operate a 45% in Spanish centers, 35% in Portuguese and a more discreet 25% in the Dutch landscape.

Figure 1.

Distribution of international universities by funding pillars



Source: Own elaboration (2024).

3.1.1. Dutch universities

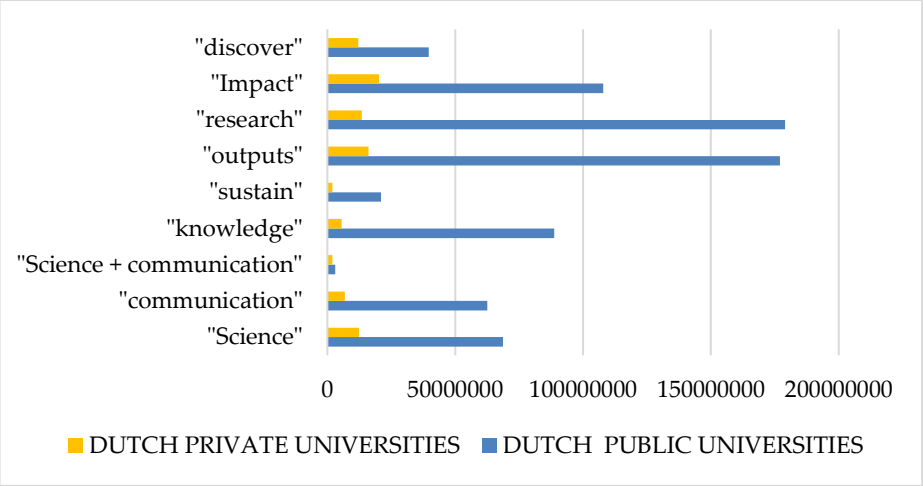
The first European country observed for this preliminary research is Netherlands, with all its public and private universities. The data extracted from the whole analysis of contents available regarding the official communications of these High Educational organizations bring strong and interesting reads (see figure 2). Terms concerning directly to “research” and “outputs” are mentioned among an impressive amount of 179M and 177M respectively in public centers, while private high schools bring them up 13M and 16M accordingly.
The label "impact" also appears with a high volume of mentions (108M) while a shorter amount (20,2M) is covered by independent universities. Messages related straight away to “knowledge” appear 88,8M times, while on the other hand a discrete total of 5,5M cites are included in independent higher education institutions. Following the same differential pattern from one typology to another, “science” tags are substantially noted (68M), followed by “communication” (62,6M) and “discover” (39,6M) within the framework of public universities, while the say terms are much less noticed in private centers, implying in the same order 12,3M, 6,9M and 12,1M.

Comparing to all the categories analyzed, the messages related to the “sustainable” approach are in the final tail of the quantitative study focused on the Netherlands, showing a total of 20,9M inputs in public universities and a contrastive 1,95M in those ruled by private

management. In last place comes the core concept of the research: feedings referring to "science communications" are displayed in much smaller quantities with just 3M mentions in state-owned institutions, while it is appreciated a more equal amount of 1,9M references regarding the same category in non-public universities.

Figure 2.

Key tags study of universities in the Netherlands at a glance



Source: Own research findings (2024).

3.1.2. Portuguese universities

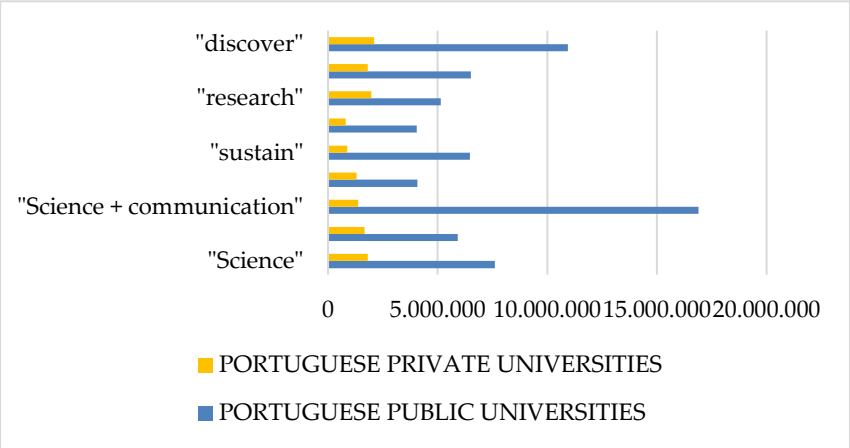
High Educational institutions in Portugal give in their official dissemination (see figure 3) regarding SC shows an impressive amount of 16,8M publications in public universities versus a discrete 1,3M in private centers. The tags related to "discover" appear also in a very high level in public universities with 10M mentions, although those privates cover a total of 2,1M references. Weighing the volume of occurrences in the content analysis, the following most mentioned tags are "science", "impact", "communication" and "research", followed by a lower presence of "sustainability", "knowledge" and "outputs".

References towards "science" references are noteworthy, with 7,6 million units directed respecting this goal, while non-state-run universities disclose it in 1,8M occasions. Close to it, when studying the degree of mentions concerning "impact" concentrated on the corporate websites of Portuguese universities, the data point to a volume of mentions of 6,5 in statal educative institutions, against a subtle 1,8M in independent universities.

Messages focused on a "sustainable" point of view, are more predominant on public universities with 6,4M citations alongside just a considerable small 877.850 allusions in the privates. The tags regarding "Communication" and "research" occupy a similar weight of presence with 5M mentions in public colleges against a warier 1,7M in private high educational schools. Similarly, the terms of "Knowledge" and "outputs" appear also equals, with 4M approximate in public universities Vs close to 1M mentions in private centers.

Figure 3.

Portuguese universities content analysis



Source: Own research findings (2024).

3.1.3. Spanish universities

Explicit communications on the corporate websites of Spanish universities (see figure 4) focus -in order of priority- on messages related to science and academic results, followed closely by publications related to communication, science communication and impact. Lastly, and to a lesser extent in comparative terms, the message of knowledge transfer, research, sustainability, and the discovery of new things from the institutions is worked on. In any case, in global terms, we are talking about millions of elements that allude to the labels selected for the study.

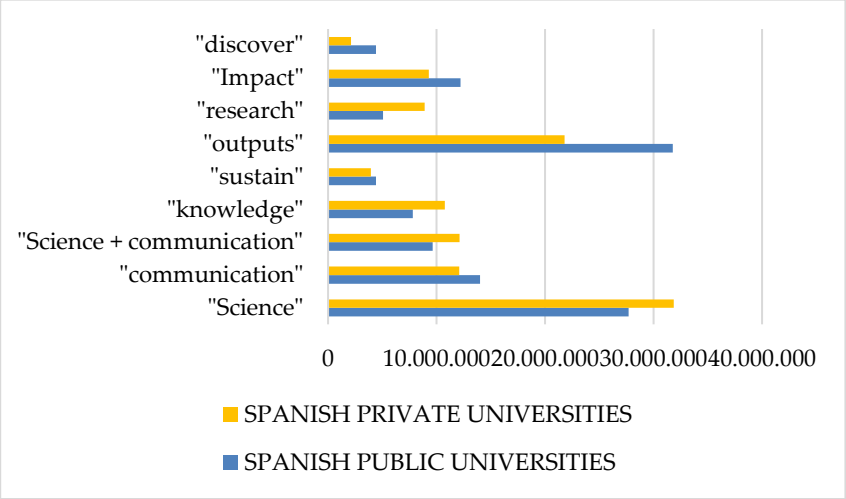
Regarding the category "science", Spanish public universities seem to engage in substantial science communication efforts, in gross terms with over 27,6M mentions dedicated to this endeavor. This reflects a commitment to sharing scientific knowledge with the public, while private universities in the country allocate also considerable resources to it, overpassing 31,8M tags. Although also notably mentioned, the "outputs" label takes on the opposite protagonism, being more present in the messages of public centers than in private ones. The concept of "science communications" appears in almost 25% more of the websites of private universities, compared to the 9,5M elements contained in the official communications of Spanish public universities.

Private institutions also emphasize more contents related to "knowledge" with 12,1 M elements allocated to this category, Vs the 7,8 M published by public universities. The "sustainable" approach of their educational and research activities is also notable, with approximately 4,5M explicit comments in public universities followed by the private centers with 3,9M mentions. "research" activities are highlighted 8,9 M in private institutions, almost the double of times of the public ones.

The "impact" concept wins in presence in public universities with 12 M tags, Vs privates with 9M elements. In the other hand, the notion of "discovery" in academia, is highlighted the double of times in public (4,4 M) Vs privates (2,1M) universities.

Figure 4.

Spanish SC framework and quantitative analysis



Source: Own research findings (2024).

3.2. Digital communications among international samples

Consecutively, a comparative analysis is carried out in absolute terms between countries and key tags. As a result, a series of outputs are obtained that allow to see which places are having the greatest impact (see table 3 and figure 5) on terms related to SC and the dissemination of knowledge transfer for educational and awareness-raising purposes to the stakeholders that seek information in the official sources of these universities.

Table 3.

Convergences and divergences per tag and country

COUNTRY	"science"	"communication"	"science + com*"	"knowledge"	"sustain*"	"outputs"	"research"	"impact"	"discover*"
NETHERLANDS	80,1	69,4	5	94,3	22,9	193,1	192,5	128,2	51,7
PORTUGAL	9,5	7,6	18,3	5,4	7,3	4,8	7,1	8,3	13
SPAIN	59,6	26,1	21,7	18,5	8,4	53,6	14	21,5	6,5

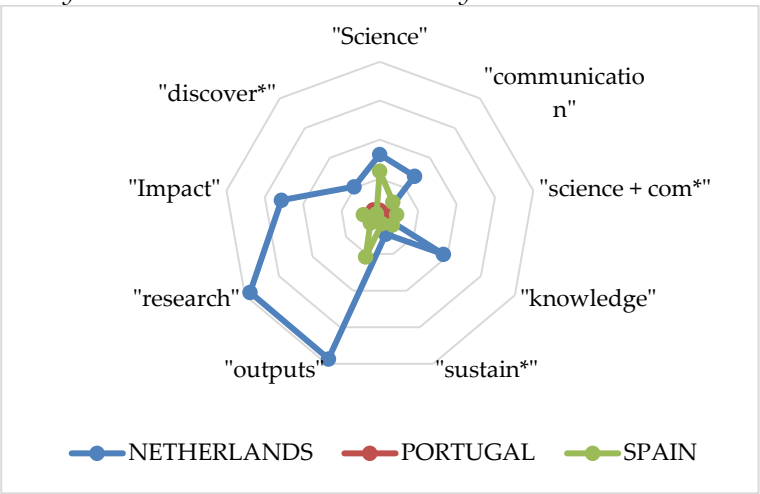
Source: Own elaboration (2024).

Universities allocated in the Netherlands are the most active when communicating all kind of tags related to the core concept, with a wide spectrum of references coming from 193,1M tags for "research outputs" to 5M "science + communication" entrees. It is followed in terms of volume of activity by Spain, with a range from top "science" category with 59,6M results, to a bottom line of 6,5M quotes for "discover". Finally, Portugal presents a more discrete gross result that wave from peak "science + communication" section with 18.3M results, to a minimum of 4,8M mentions regarding "outputs".

However, with regard to the explicit concept of "SC", the weights per country vary, being Spain the country that includes it most directly in its messages (21,7M), followed by a major effort in Portugal, which gives it top priority (18,3M) over the other labels in the same category (see figure 5), and lastly the Netherlands, which communicates it on a total of 5M occasions through its educational institutions.

Figure 5.

Radial comparative analysis towards SC and sustainability



Source: Own research findings (2024).

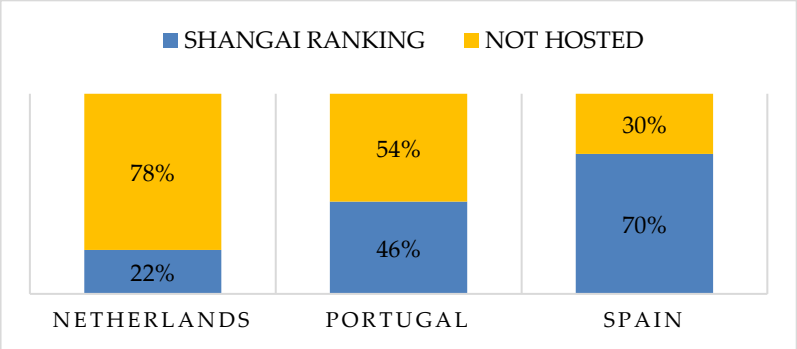
In comparative terms, the level of direct references towards sustainability is much lower than other tags analyzed, being in any case much more present in the Netherlands (22,9M), and to a much lesser extent in Spain (8,4M) and Portugal (7,3M).

3.3. Academic and scientist impact value

Analyzing in detail the evaluation of public high educational institutions in international rankings -specifically according to the ARWU as it is considered for many as the guiding classification in the general university guidelines- 70% of Spanish universities, 46% of Portuguese universities and 22% of the total sample from the Netherlands, are currently indexed in this ranking (see figure 6).

Figure 6.

Ratio of universities indexed to ARWU 2023



Source: Study findings (2024).

Zooming public universities to see the position they occupy in this worldwide ranking (see table 4), Spain shows the larger number of universities included in the 2023 list with n=35, where the country's 2 top-rated universities (6% of the total national sample) appear in the 201-300 range. Meanwhile, the Netherlands (n=13) stands out with its 3 top-rated universities (23%) in the world's top 100. Last but not least, Portugal with n=6, brings an interesting 33% of high educative institutions which tops its national list, occupying at the same time a global post in the 201-300 step level.

Table 4.

Distribution per global acknowledge in the Shanghai Ranking

ARWU 23	NETHERLANDS (n=13)	PORTUGAL (n=6)	SPAIN (n=35)
〈100	23%	0%	0%
101-150	23%	0%	0%
151-200	23%	0%	0%
201-300	8%	33%	6%
301-400	0%	0%	14%
401-500	15%	50%	3%
501-600	0%	0%	9%
601-700	0%	17%	17%
701-800	8%	0%	20%
801-900	0%	0%	9%
901-1.000	0%	0%	23%
	100%	100%	100%

Source: Own elaboration (2024).

In relative terms, the critical mass of the best-ranked universities is comprised mainly by Dutch universities, followed by Portuguese and lastly by Spanish, which offsets these weights by a higher volume of universities included in the world ranking, even if they are valued at the tail end of the distribution.

To study possible correlations between the public universities indexed in the ARWU 2023, the position they occupy, and the volume of activity of messages related to the global computation of SC-related tags, a dynamic analysis is carried out. The raw data is cleaned to the average of the 9 tags per university, so they can be analyzed in a synthesized manner. Afterwards, a dynamic table is established to show the distribution of the volume of posts related to sustainability and science communication by rank in the different international academic contexts (see table 5). By doing so, the information is organized by country, average sum, and total average number of posts for each rank.

Among the outputs generated in tables 4 and 5, the following results are noteworthy, with the aim of to gain a deeper understanding of correspondence between communicative strategies and successful impact on qualitative and quantitative standards for the top educational organizations:

I.By volume of activity and country, the matrix is headed by Spain with 11,9M posts, followed by Portugal with 5,4M posts and the Netherlands with only 479.684 posts. This means a net average per university/country of 339.000, 903.027, and 36.899 respectively.

II.In the case of Spain, the first activity in the ARWU is occupied by 6% of the total number of public universities indexed in the ranking at the 4th level (201-300), with a cumulative average volume of 232.289 entries, which represents a net average of 116.145 per center (value/ n=2). The most highlighted Spanish activity occur in: a) the 301-400 intervals, with a cumulative average of 4,1M which represents an average of 830.497 entries for each of the 5 organizations that occupy it (14%); and b) the 501-600 interval, with 3 universities (9%) that generate a net average of 1,2M each. However, in the last bracket of the ranking (901-1.000), 23% of Spanish universities are covered, with an average total of 934.749, and an average distribution of 116.844 entries.

III.Out of the 13 public higher education institutions in Portugal, the 46% (n=6) are included in the international ranking, presenting a grouping behavior in 3 intervals: 33% in the 201-300 range, 50% in the 401-500 bracket, and 17% in the 601-700 interim.
Nevertheless, between them all, they give an average gross average of 5,4M communications, which implies an average per university of 903.027 entries. It is also worth noting that a 17% (a single Portuguese university) hosted in the 601-700 range, generates itself a total of 3,4M entries.

IV.Observing the small total of 13 Dutch universities indexed in the Shanghai ranking (from a total of 41 public universities) , it is striking that 23% of them have a combined gross volume of 48.113 publications in the first level of the cut-off (n<100), while the third level (range 151-200) also has 23% with 265.453 entries. Meanwhile, in the 23% of the intermediate range of the second step of the ranking (101-150), there is an accumulated average of 31.280 mentions. It is also worth noting that 92% of the cases occupy the first 5 cut-off levels of the ranking, up to position 500.

Table 5.

Cross-country analysis of universities by rank and average digital SC

POST	NETHERLANDS	PORTUGAL	SPAIN	Total per rank
52	5.795			5.795
76	40.449			40.449
88	1.869			1.869
101-150	31.280			31.280
151-200	265.453			265.453
201-300	16.330	1.120.545	232.289	1.369.164
301-400			4.152.483	4.152.483
401-500	86.477	912.281	333.111	1.331.869
501-600			3.521.702	3.521.702
601-700		3.385.333	1.165.535	4.550.868
701-800	32.031		681.580	713.611
801-900			843.566	843.566
901-1.000			934.749	934.749
Average per university	36.899	903.027	339.000	
Total average per country	479.684	5.418.159	11.865.015	17.762.858

Source: Own elaboration (2024).

4. Debate and Conclusions

The original premise of this research is the assumption that science communication is a vital component of education sciences, with the potential to transform learning experiences and foster societal engagement with science. To this purpose, high education institutions have a direct responsibility to share its knowledge (Davies, 2021) and outputs to all stakeholders, using their official communicative tools, taking advantage to the global impact of their digital corporate websites to reach wider targets. Therefore, we are discussing the concept of sustainability understood not only in environmental terms, but also as the enduring visibility and impact of the most relevant academic scientific achievements from universities.

Reputation and credibility of messages can create a very interesting sustained competitive advantage for public universities (Miotto et al., 2020), which favors the maintenance of institutions at the levels they occupy in international rankings, if not even better, to rise to higher positions within the scale.

Regarding the 3 research questions posed initially, after analyzing the data obtained, the answers (RA) are given in the same following order.

- RA1. Digital science communication from public and private universities

Overall, the degree of inclusion of the keywords selected for the study is very high, involving millions of references in many cases, which supports the perspectives of Thorp (2020) that indeed Academia and researchers are facing growing demands to convey their scientist findings to all stakeholders, and the viewpoint of Besley et al. (2020) when observing that higher education institutions are fostering societal appreciation for science.

Regarding the differences by country and origin of management, in Spain there is a stronger dissemination by public institutions, except in the case of the generic treatment of the concept of science, knowledge and SC, in which case they are slightly more widespread in the case of private institutions. In Portugal and the Netherlands, the majority presence of communications related to sustainability and SC in public educational institutions is much bigger and clearer.

- RA2. Sustainable messages according to the type and nationality of institutions

The use of keywords to proactively share practices and debates on scientific life from each country seem to be marked by their intrinsic cultural preferences. Thus, the Netherlands has the highest overall activity rate, followed by Spain and then Portugal. However, "fetish" words appear in each nation, for example "knowledge" is widely used in the Netherlands and very little used in Portugal. Similarly, "research" is very popular in the Netherlands, but much less used in Spain. Mentions related to "outputs" are very common in the Netherlands and Spain, while among the favorite terms in Portugal are "science communications" and "discover".

Sustainability is applied in a high percentage, although to a considerably lesser extent than the other concepts, probably because it is not yet considered as a matter directly linked to the impact of science on society, at least at the level of institutional digital communication. This approach would be also in line with the perspective of the deficit model of knowledge transmission (Seethaler et al., 2019) which attributes as probable causes a still weak research influence in practice, and resistance to change in the way of communicating and choosing content for digital environments.

- RA3. Ranked universities sharing outputs to promote knowledge transfer

A large number of Spanish universities are indexed in the ARWU, in juxtaposition to the case

of Portugal, where a minority are currently on the rating grid. In the case of the Netherlands, almost half of the entire sample is indexed at relatively higher values than its EU sister countries. Reading data on average, the Portuguese universities indexed in the Shanghai ranking are making more digital communications to the community, followed by the Spanish ones and with a very discreet low volume of publications in the Dutch indexed ones.

Although the Dutch public universities that appear in the international ranking show greater activity, it is striking that those that are better positioned have a much lower level of digital communication than those positioned from 151-200, perhaps because, as a result of their consolidated prestige over the years, they do not consider it strategic to increase the volume of their dialogue with stakeholders to favor their inclusion and involvement (Grunig, 2023), and also in order to avoid saturating them with messages.

In summary, the analysis reveals distinct communication patterns among European universities: Spanish institutions exhibit a higher frequency of messages which allude in some way to science communication, while Dutch universities, although with a lower general volume, demonstrate a more concentrated focus on sustainability topics. Moreover, in stakeholder management, quantitative endeavors in digital media appear more pronounced among public institutions; however, the quality of these efforts emerges as a crucial factor. Despite Spain leading in the gross value of online corporate communications, Dutch and Portuguese public universities receive comparatively higher global academic recognition.

4.1. Improvements and further steps

As a result of this preliminary work, the need for further research is proposed to better understand the cultural differences in behavioral patterns when communicating science, its challenges, and its results through the universities' own digital platforms. To this end, the next milestone is to conduct in-depth interviews with key agents at these European universities to corroborate the alignment between the chosen strategy -whether there is an executive communication plan-, the target international positioning, and the return of the image perceived in terms of the value assigned by the ARWU. On the other hand, it would be interesting to replicate the study covering other member countries, to provide a more complete view of the entire European framework. This would allow a deeper understanding of current practices in science dissemination and knowledge transfer, culture, the quality of messages, and their recognition as a strategic element for the sustainability of their impact on society, to leverage innovation, development, and integration into everyday life.

5. References

Alzubi, Y. (2018). Knowledge transfer for sustainability. *World Journal of Science, Technology and Sustainable Development*, *15*(4), 325–337. https://doi.org/10.1108/wjstsd-04-2018-0023

Anderson, A. A., Scheufele, D. A., Brossard, D., & Corley, E. A. (2011). The Role of Media and Deference to Scientific Authority in Cultivating Trust in Sources of Information about Emerging Technologies. *International Journal of Public Opinion Research*, *24*(2), 225–237. https://doi.org/10.1093/ijpor/edr032

Babones, S. (2015). Interpretive Quantitative Methods for the Social Sciences. *Sociology*, *50*(3), 453–469. https://doi.org/10.1177/0038038515583637

Bennett, N., Dudo, A., & Besley, J. C. (2022). The form and function of U.S.-based science communication fellowship programs: interviews with program directors. International

Journal of Science Education, Part B, *13*(3), 230–244. https://doi.org/10.1080/21548455.2022.2155495

Besley, J. C., Newman, T. P., Dudo, A., & Tiffany, L. A. (2020). Exploring scholars' public engagement goals in Canada and the United States. *Public Understanding of Science*, *29*(8), 855–867. https://doi.org/10.1177/0963662520950671

Bucchi, M.; Trench, B. (2021), *Routledge Handbook of Public Communication of Science and Technology*, 3rd ed.; Routledge. https://doi.org/10.4324/9781003039242

Capers, R. S., Oeldorf-Hirsch, A., Wyss, R., Burgio, K. R., & Rubega, M. A. (2022). What Did They Learn? Objective Assessment Tools Show Mixed Effects of Training on Science Communication Behaviors. *Frontiers in Communication*, (6). https://doi.org/10.3389/fcomm.2021.805630

Chinn, C. A. & Duncan, R. G (2018). What is the value of general knowledge of scientific reasoning? In, Fischer, F., Chinn, C. A., Engelmann, K., & Osborne, J. (eds.), *Scientific reasoning and argumentation: The roles of domain-specific and domain-general knowledge* (pp. 77–101). Routledge. https://doi.org/10.4324/9780203731826-5

Cooper, C. B., Hawn, C. L., Larson, L. R., Parrish, J. K., Bowser, G., Cavalier, D., Dunn, R. R., Haklay, M. (Muki), Gupta, K. K., Jelks, N. O., Johnson, V. A., Katti, M., Leggett, Z., Wilson, O. R., & Wilson, S. (2021). Inclusion in citizen science: The conundrum of rebranding. *Science*, *372*(6549), 1386–1388. https://doi.org/10.1126/science.abi6487

Davies, S. R. (2020). An Empirical and Conceptual Note on Science Communication's Role in Society. *Science Communication*, *43*(1), 116–133. https://doi.org/10.1177/1075547020971642

Dawson, E. (2014). Reframing social exclusion from science communication: moving away from 'barriers' towards a more complex perspective. *Journal of Science Communication*, *13*(02), C02. https://doi.org/10.22323/2.13020302

De Sola Pool, I., & Berelson, B. (1952). Content Analysis in Communication Research. *American Sociological Review*, *17*(4), 515. https://doi.org/10.2307/2088029

Dudo, A., Brossard, D., Shanahan, J., Scheufele, D. A., Morgan, M., & Signorielli, N. (2010). Science on Television in the 21st Century. *Communication Research*, *38*(6), 754–777. https://doi.org/10.1177/0093650210384988

Entradas, M., & Bauer, M. M. (2016). Mobilisation for public engagement: Benchmarking the practices of research institutes. *Public Understanding of Science*, *26*(7), 771–788. https://doi.org/10.1177/0963662516633834

European Commission, Directorate-General for Education, Youth, Sport and Culture, (2022). *Education and training monitor 2022*. https://op.europa.eu/webpub/eac/education-and-training-monitor-2022/en/country-reports/country-reports.html

Eurostat (2023). Country facts. https://ec.europa.eu/eurostat/cache/countryfacts/#

Fähnrich, B., Wilkinson, C., Weitkamp, E., Heintz, L., Ridgway, A., & Milani, E. (2021). Rethinking Science Communication Education and Training: Towards a Competence

Model for Science Communication. *Frontiers in Communication*, (6). https://doi.org/10.3389/fcomm.2021.795198

Fecher, B., Kuper, F., Sokolovska, N., Fenton, A., Hornbostel, S., & Wagner, G. G. (2021). Understanding the Societal Impact of the Social Sciences and Humanities: Remarks on Roles, Challenges, and Expectations. *Frontiers in Research Metrics and Analytics*, (6). https://doi.org/10.3389/frma.2021.696804

Gobierno de España. Ministerio de Universidades (2023). *Registro de Universidades, Centros y Títulos (RUCT).* https://www.educacion.gob.es/ruct/consultauniversidades?actual=universidades

Grunig J. E. (2023). Public Relations, Social Inclusion, and Social Exclusion. *Journalism & Communication Monographs*, *25*(2), 90–108. https://doi.org/10.1177/15226379231167120

Gustafson, A., & Rice, R. E. (2020). A review of the effects of uncertainty in public science communication. *Public Understanding of Science*, *29*(6), 614–633. https://doi.org/10.1177/0963662520942122

Haklay, M.M.; Dörler, D.; Heigl, F.; Manzoni, M.; Hecker, S.; Vohland, K. What is citizen science? The challenges of definition. In Vohland, K., et al. (eds.), *The Science of Citizen Science* (pp. 13-33). Springer. https://doi.org/10.1007/978-3-030-58278-4_2

Hmielowski, J. D., Feldman, L., Myers, T. A., Leiserowitz, A., & Maibach, E. (2013). An attack on science? Media use, trust in scientists, and perceptions of global warming. *Public Understanding of Science*, *23*(7), 866–883. https://doi.org/10.1177/0963662513480091

Instituto Geográfico nacional (2023). España en el mundo. https://www.ign.es/espmap/mapas_mundo_bach/pdf/Mundo_Mapa_01_texto.pdf

Judd, K., & McKinnon, M. (2021). A Systematic Map of Inclusion, Equity and Diversity in Science Communication Research: Do We Practice what We Preach? *Frontiers in Communication*, 6. https://doi.org/10.3389/fcomm.2021.744365

Lewenstein, B. V., & Baram-Tsabari, A. (2022). How should we organize science communication trainings to achieve competencies? *International Journal of Science Education*, Part B, *12*(4), 289–308. https://doi.org/10.1080/21548455.2022.2136985

Lozano, J. M., Bofarull, I., Waddock, S., & Prat-i-Pubill, Q. (2018). Avoiding the Iron Cage of Business School Rankings. *Higher Education Policy*, *33*(1), 135–157. https://doi.org/10.1057/s41307-018-0107-7

Mahdi, O. R., Nassar, I. A., & Almsafir, M. K. (2019). Knowledge management processes and sustainable competitive advantage: An empirical examination in private universities. *Journal of Business Research*, (94), 320–334. https://doi.org/10.1016/j.jbusres.2018.02.013

Martins, V. W. B., Rampasso, I. S., Anholon, R., Quelhas, O. L. G., & Leal Filho, W. (2019). Knowledge management in the context of sustainability: Literature review and opportunities for future research. *Journal of Cleaner Production*, (229), 489–500. https://doi.org/10.1016/j.jclepro.2019.04.354

Miotto, G., Del-Castillo-Feito, C., & Blanco-González, A. (2020). Reputation and legitimacy: Key factors for Higher Education Institutions' sustained competitive advantage. *Journal of Business Research*, (112), 342–353. https://doi.org/10.1016/j.jbusres.2019.11.076

Neuberger, C., Nuernbergk, C., & Langenohl, S. (2018). Journalism as Multichannel Communication. *Journalism Studies*, *20*(9), 1260–1280. https://doi.org/10.1080/1461670x.2018.1507685

Riffe, D., Lacy, S., Fico, F., Riffe, D., Lacy, S., & Fico, F. G. (2006). *Analyzing Media Messages*. Routledge. https://doi.org/10.4324/9781410613424

Seethaler, S., Evans, J. H., Gere, C., & Rajagopalan, R. M. (2019). Science, Values, and Science Communication: Competencies for Pushing Beyond the Deficit Model. *Science Communication*, *41*(3), 378–388. https://doi.org/10.1177/1075547019847484

Statistics Netherlands (CBS). (2023). https://www.cbs.nl/en-gb

Stemler, S. (2001). An overview of content analysis. *Practical Assessment, Research & Evaluation*, *7*(17), 137-146.

Teixeira, S. J., Veiga, P. M., & Fernandes, C. A. (2019). The knowledge transfer and cooperation between universities and enterprises. *Knowledge Management Research & Practice*, *17*(4), 449–460. https://doi.org/10.1080/14778238.2018.1561166

Thorp, H. H. (2020). Stick to science. *Science*, 367(6474), 125–125. https://doi.org/10.1126/science.aba7714

Wedlin, L. (2011). Going global: Rankings as rhetorical devices to construct an international field of management education. *Management Learning*, *42*(2), 199–218. https://doi.org/10.1177/1350507610389683

AUTHOR CONTRIBUTIONS, FUNDING AND ACKNOWLEDGEMENTS

Author Contributions:

Conceptualization: Torres-Mancera, R., and Martínez-Rodrigo, E. **Methodology and software:** Torres-Mancera, R. **Validation:** Martínez-Rodrigo, E. **Formal analysis:** Torres-Mancera, R. **Data curation:** Torres-Mancera, R., and Martínez-Rodrigo, E.**; writing—original draft preparation:** Torres-Mancera, R. **writing—review and editing:** Torres-Mancera, R., and Martínez-Rodrigo, E. **Visualization:** Torres-Mancera, R. **Supervision:** Torres-Mancera, R., and Martínez-Rodrigo, E. **Project administration:** Torres-Mancera, R. **All authors have read and agreed to the published version of the manuscript:** Torres-Mancera, R., and Martínez-Rodrigo, E.

Funding: Study supported by the Margarita Salas Requalification Grant from the Spanish Ministry of Universities and the European Union -Next Generation EU for the period 2022-24.

Data Availability Statement: For access to the data samples and comprehensive coding procedures, please reach out to the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

AUTHORS:

Rocio Torres-Mancera
University of Malaga. Spain.

Psychologist and International Industrial Doctor in Communication with a guest research stay held at the University of Oxford. Executive MBA by IE Business School, Master Degrees in Business Communication and Advertising, HR Management, Local Economic Development and Strategic Management and Innovation in Communication (Extraordinary Award). Researcher and teaching collaborator with stays also in the Netherlands, Portugal and Mexico. Currently, her research work is supported by the Margarita Salas Scholarship at the University of Granada. She has more than 20 years of professional experience and collaborates in European Erasmus + Projects for the international culture of sustainable development.

rociotorres@uma.es

Orcid ID: https://orcid.org/0000-0002-7205-5639
Google Scholar: Rocío Torres-Mancera 0000-0002-7205-5639
ResearchGate: https://www.researchgate.net/profile/Rocio-Torres-Mancera
Academia.edu: https://uma.academia.edu/RocioTorres
Dialnet: https://dialnet.unirioja.es/servlet/autor?codigo=4406131

Estrella Martínez-Rodrigo
University of Granada. Spain.

PhD in Audiovisual Communication and Advertising, Professor of the Department of Information and Communication at the University of Granada, in the Faculty of Communication and Documentation. She is responsible for the Research Group "Cyberculture, communicative processes and audiovisual media" of the Andalusian Regional Government (SEJ-508). Her research lines and publications focus on audiovisual communication, social networks, and science communication, especially regarding to its social, cultural and educational effects. She has participated in various national and international research projects and has directed several doctoral theses on these topics.

emrodrigo@ugr.es

Orcid ID: https://orcid.org/0000-0002-8063-0525
Google Scholar: Estrella (Stella) Martínez-Rodrigo
ResearchGate: https://www.researchgate.net/profile/Estrella-Martinez-Rodrigo
Academia.edu: https://granada.academia.edu/EstrellaMart%C3%ADnezRodrigo
Dialnet: https://dialnet.unirioja.es/servlet/autor?codigo=3038334