

Article

Spanish Archaeological Museums during COVID-19 (2020): An Edu-Communicative Analysis of their Activity on Twitter through the Sustainable Development Goals

Pilar Rivero, Iñaki Navarro-Neri, Silvia García-Ceballos * and Borja Aso

Department of Specific Didactics, Faculty of Education, University of Zaragoza, Calle de Pedro Cerbuna, 12, 50009 Zaragoza, Spain; privero@unizar.es (P.R.); inakinavarro@unizar.es (I.N.-N.); basom@unizar.es (B.A.)

* Correspondence: sgceballos@unizar.es; Tel.: +34-876-554-865

Received: 22 September 2020; Accepted: 2 October 2020; Published: 6 October 2020

Abstract: On 18 March 2020, Spanish museums saw their in-person activities come to a halt. This paradigm shift has raised questions concerning how these institutions reinvented themselves and modified their edu-communicative strategies to promote heritage through active citizen participation. The present study centers on analyzing how the main Spanish archaeological museums and sites ($N = 254$) have used Twitter as an edu-communicative tool and analyzes the content of their hashtags through a mixed methodology. The objective is to identify the educational strategies for both transmitting information as well as interacting with users. We did it by observing and analyzing if Spanish archaeological institutions are promoting a type of quality, accessible, and egalitarian education and promoting the creation of cyber communities that ensure the sustainability of heritage through citizen participation. This paper proposes an innovative assessment of communication on Twitter based on the purpose of messages from the viewpoint of heritage education, their r-elational factor, and predominant type of learning. The main findings reveal a significant increase in Twitter activity, both in quantitative and qualitative terms: educational content is gaining primacy over the simple sharing of basic information and promotional content. The networks forge new ways to teach–learn and interact with media and represent a strong channel to promote the sustainability of heritage, its preservation, and appreciation.

Keywords: archaeological museums; cultural heritage; open-air museums; COVID-19; Twitter; hashtag; heritage education; R-factor; edu-communication; sustainability

1. Introduction

The breakneck speed at which digital society and culture have advanced over the last 20 years has given rise to various new areas of research, such as the study of digital edu-communication, which has proven itself to be fundamental for life-long and non-formal learning. In parallel, heritage education has evolved from being entirely focused on the physical and material towards also being engaged with the virtual [1]. The use of social media has given way to new educational possibilities through a type of user interaction that is both accessible and massive. As a result, it is now possible to interact with heritage sites from anywhere in the world [2].

In recent years, edu-communication on social networks has become a mainstay for a wide array of institutions to exchange and share content [3], leading to an ideal context for the better appreciation of culture [4] and heritage education [1,5]. The digital realm is well disposed to the open and flexible creation of knowledge-forming processes as well as the understanding, appreciation, awareness, and enjoyment of cultural heritage. All of this makes social networks a

potentially educative medium within a larger global context [6,7] that offers us an opportunity for citizen participation. Accordingly, a range of studies have analyzed the extent to which digital environments democratize, educate, and socialize heritage [8–10]. Digital learning is a process that is not subject to normal restrictions and has changed the rules of the game, providing new communication tools and spaces for interaction [1,11]. In this vein, social networks have emerged as powerful instruments and platforms for museums to communicate on a massive scale with their publics [12–17], even becoming publication spaces for these institutions [18] and forging new inter-institutional relationships as a part of trends in online communication [19] allowing us to educate, raise awareness, and value the wealth of heritage and its necessary conservation to promote the sustainability of our legacy.

All these elements of analysis are framed within some of the 17 Sustainable Development Goals. Specifically, this research aims to analyze whether in Goal 4, "Guarantee inclusive, equitable and quality education and promote lifelong learning opportunities for all", institutions are providing the tools to achieve "an education that fosters sustainable development and sustainable lifestyles, human rights, gender equality, the promotion of a culture of peace and non-violence, world citizenship and the appreciation of cultural diversity and the contribution of culture to sustainable development, etc." (Target 4.7) [20]. Finally, this study also tries to analyze whether in Goal 11, "Make cities more inclusive, safe, resilient and sustainable", the Spanish institutions analyzed have tried to "redouble their efforts to protect and safeguard cultural and natural heritage of the world" (Target 11.4) [21]. In this sense, the necessary reinvention of culture is underlined and with it the self-management systems that make its sustainability possible, as well as awareness and commitment to the content they promote, knowledge of the goods, and the necessary care for the preservation of its wealth and its transmission from generation to generation [22].

The heritage-based edu-communicative strategies used by museums constitutes an emerging field of research within which the present study focuses on the collection of Spanish archaeological and open-air museums and these institutions' use of Twitter. This platform has been identified as a fruitful area of study due to its ability to foster multi-directional communication about topics of interest that are clearly marked and searchable through the use of hashtags. Archaeological museums can be included among the larger group of museums that count on the greatest number of digital resources, reconstructions, augmented reality, and virtual reality tools as well as virtual visits [1]. That said, it remains necessary to conduct an in-depth study of how archaeological museums use online resources to foster edu-communicative processes and create knowledge. The present paper takes significant steps towards addressing this issue.

2. Materials and Methods

In light of previous analyses concerning the possible advantages of social networks for heritage education [2,23,24], it has been determined that a hashtag on Twitter, which is linked to specific educational content and is used in a periodic or regular fashion (for example, on a weekly basis or even more frequently), can enjoy substantial diffusion and be combined with other communicative strategies for piquing user interest and ultimately leading to meaningful learning. Even if current society is characterized by a desire for the immediate, ephemeral trends and impatience [25], Twitter is well-equipped to generate group discussions about concrete issues, which, if they reach a large enough audience, become trending topics that are identified with specific hashtags [26]. The present study analyses the content tied to the most notable hashtags used by archaeological museums during the health crisis unleashed by COVID-19. It does so through a reflection on hashtags' educative goal, possibility of encouraging participation, exchange, and learning opportunities that are offered by museums and the presence of messages that explicitly or implicitly promote the sustainability of the heritage. Therefore, this paper seeks to answer the following research questions: What are the forms of educational interaction that museum communication departments are offering on twitter? What strategies and contents are they using to stimulate a multidirectional edu-communication?

This study fits into a larger ongoing line of research concerning the role of cultural institutions on Twitter and/or other social media platforms, which has been underway since 2012 [13,27,28]. This research has also produced recent doctoral dissertations [29–31] that offer new models for analyzing content and use research standards in the field that had previously only been discussed theoretically. The methodological focus of this research is based in the didactic-contextual genealogy of heritage [32,33] and in the processes of interpretation, communication, and diffusion of heritage [34,35].

2.1. Objectives and Research Questions

The main objective of the present study is to analyze the Twitter activity of Spanish archaeological and open-air museums during the lockdown resulting from the COVID-19 pandemic and whether this activity enables the fulfillment of some of the objectives for sustainable development related to education and heritage. Within this larger umbrella, there are the following specific objectives (SO):

- SO1. To quantify the activity generated on Twitter by Spanish archaeological and open-air museums over the last several years.
- SO2. To compare the participation of institutions in #MuseumWeek 2020 with the level of participation in previous years.
- SO3. To identify different edu-communicative proposals through an analysis of museums' use of hashtags with a clear focus on each message's purpose, the relational factor, and predominant type of learning.

Therefore, the present study answers the following research questions: What is the current state of Spanish archaeological and open-air museums' Twitter activity? Has the physical closure of museums led to a greater effort on museums' part to participate in concrete initiatives such as #MuseumWeek? Has the lockdown led to new 2.0 communicative strategies that demonstrate the viability of edu-communicative projects requiring online participation? Is heritage sustainability promoted through social media?

2.2. Sample

The sample for this study was gathered from the information catalogued on the Directory of Museums and Collections of Spain, which is available on the Ministry of Culture and Sport's website. The keywords "arqueológico" and "de sitio" were used to search the list by topic and yielded an initial sample of 254 different institutions. From this larger list, a search was conducted to determine which institutions had an official Twitter account. This search brought the sample down to 59 (i.e., 23.2% of the original list) institutions that had profiles clearly marked as officially belonging to the institution.

The next selection criterion was the level of institutions' Twitter activity. Only 31 institutions had profiles that showed at least one example of an activity that was sufficiently constant and planned. This selection criterion was determined with a minimum number of posts over a certain period of time: 3 to 5 tweets a week that contained the institution's own content. Only 12.2% of all Spanish archaeological institutions have an official Twitter account whose activity can be characterized as planned, constant, and possibly of value in edu-communicative terms.

Finally, from this reduced sample, the study only took into account hashtags that were used by institutions in at least 40 tweets. This quantity of tweets (i.e., 40) require a good and consistent management of a hashtag, given that it would have been used approximately 3 to 5 times a week during the lockdown. Furthermore, this volume allows us to speak in terms of a broad and consistently used edu-communicative process, which can be found using the platform's search tools and subsequently analyzed in terms of the public's response over a period of time would elude to the sort of one-off events that have become so characteristic on the web 2.0 [36].

In total, 213,571 tweets have been analyzed. These come from 31 different institutions, which have been active on Twitter during the last 5 years. We have identified a total activity in which only 52,408 (24.5%) tweets reflect an institution's own original communication with at least one hashtag.

2.3. Analytic Instrument: Heritage Education, R-relational Factor, and Learning Proposal

The first phase of research, which was part of a broader project, consisted in creating a research tool that could be used to classify the edu-communicative processes of museums on Twitter. This research instrument focused on three fundamental pillars: first, the procedural sequence for heritage education [33]; second, the so-called r-relational factor, which has been recently formulated in several studies [37,38]; third, the predominant type of learning in educational terms [39]. In addition, other articles that discuss important aspects of the theory of heritage-based edu-communication have been taken into account [1,32,35].

The first pillar analyses tweets from the viewpoint of heritage education and identifies five different goals for a tweet [33]: (1) transmission is when the tweet is purely informative, providing objective facts about a piece; (2) participation is when the institution launches a project that requires followers to participate or collaborate; (3) comprehension/reflection is when the an institution shares an image, update, or video that asks suggestive questions and foments reflection that can lead a user to develop his/her own critical idea; (4) valuation is when an institution seeks to awaken the desire to protect and respect an object or site of value (either in material or immaterial terms) that is deemed at risk and has become the subject of public debate; finally, (5) enjoyment and transference is when an institution shares images, videos, updates (etc.) that can excite positive emotions.

The second pillar identifies the so-called "r-relational factor" of tweets [37], which is understood as the through line that connects use, consumption, and interaction between the online community and which makes it possible to move from ICTs (information and communication technologies) to RICTs (relations, information, and communication technologies) in which the relational aspect encourages users to analyze content, develop their own critical thinking abilities, as they look for new information and develop intellectually [40]. Within this factor, four different levels of relation can be distinguished: first and most common is when there is no attempt to form a connection between an institution and individual; the second is when interaction is only sought out through a question-and-response form through the use of surveys, open or closed questions, etc.; the third possibility requires reflection that results from the use of questions and when the user is asked to give his/her point of view with the institution serving as the catalyst for these reflections. The fourth possibility, which is the most fruitful and also happens to be the most difficult to achieve, requires cocreation that results from an institution proposing a transformative, creative, and collaborative activity whose final result is a new product that arises from users' contributions. To give an example: an institution asks visitors for photographs from their visits or the institution proposes that users send photos or videos from home in which they imitate or replicate a work from the museum's collection. Products of this type of relationship can be digital creations, creative interventions, reinterpretations, etc.

Finally, the third pillar centers on the predominant type of learning [39]. While it remains true that the majority of tweets are purely informative and/or promotional (this being a type of communication that is so rooted in all sorts of cultural institutions), we can nevertheless distinguish to a greater or lesser extent the influence of the four main learning theories on the type of learning that museums attempt to promote: behaviorism, cognitivism, constructivism, and connectivism, the final being directly linked to the emergence of ICTs and digital society.

To start, the method for data collection and analysis used analytical tools that measure activity on social media (in this case Twitter) [36]; this made it possible to analyze activity in quantitative terms, often including the total amount of Twitter activity from the time that an account was created; this analysis revealed instances of institutional profiles with low levels of activity. On the other hand, the study relied on a research instrument for analyzing heritage edu-communication on the web 2.0 (see Table 1), which is composed of three variables for analysis and 14 indicators. This instrument has been reviewed by a group of 12 experts in terms of suitability, clarity, coherence, and

relevance [41]. This review phase resulted in various changes: the language used in several descriptors has been simplified; descriptors were eliminated that were thought to be repetitive or needed to be further subdivided; items for variable 1 were combined and descriptors 2.4 and 3.5 were added.

Table 1. Analytical tool for heritage edu-communication on the web 2.0.

| VARIABLES | INDICATORS | DESCRIPTORS |
|--|---|--|
| 1. Purpose of the message (Heritage Education) | 1.1 Purely transmissive, to make information known | The main objective is to inform and bring a museum's collection closer to the public by contextualizing the works or any other academic data related to a work. |
| | 1.2 Participatory and interactive proposals | The main objective of the post is to spur the participation/involvement of Internet users |
| | 1.3 Give tools for understanding | The post mainly provides content of a reflective nature. |
| | 1.4 Promotes values of stewardship, protection, and respect | Tries to involve the public so that heritage can come to be understood as an active part of society. |
| | 1.5 Enjoy and transfer | Involves users to integrate them into the museum's activities, projects, contests, webquests, etc., enjoying the process. |
| 2. R-elational Factor | 2.1 Interaction (demonstrative) | Type of interaction: behavioral, question–answer (quizzes, trivia, password, etc.). |
| | 2.2 Reflection (interpretative) | Through questions, fosters a critical dimension, helps to interpret. |
| | 2.3 Co-creation (constructive) | Transformative, creative, collaborative. |
| | 2.4 Non-applicable | Does not seek participation. |
| 3. Dominant learning type | 3.1 Behaviorism | There is a question asked by the institution that awaits the public's answer; there is a question-and-answer dynamic (password). |
| | 3.2 Cognitivism | The tweet itself indicates where the answer is |
| | 3.3 Constructivism | Directly challenges users; appeals to socialization and the exchange of personal experiences and mixes previous knowledge with the current context. |
| | 3.4 Connectivism | It joins the initiative of another institution at the same time that it connects a current issue with an educational element of its collection; cites another institution, uses a specific appearance hashtag (a daily topic, nothing scheduled, or periodic). |
| | 3.5 Non-applicable | It is an advertisement or reply to another account |

3. Results

3.1. Archaeological and Open-Air Museums in Numbers

In the first place, the analysis of the collected data centered on extracting all data dealing with the number of followers, the trajectory of social media activity, as well as the rate and type of production. On the one hand, the total frequency of publication (including tweets, retweets, and shared content) and the tweets generated by each institution among the group of 3200 collected by the data collection tool. Thus, it became possible to contextualize the amount of new content generated by each institution. This first analysis allowed for the identification of the time that each institution had spent on the publication of tweets that were gathered by the data collection tool and

also for the identification of the most frequently used hashtags in order to classify their predominant purpose (see Table 2).

Table 2. The Twitter activity of archeological and open-air museums. The table summarizes the number of followers, activity, and most-used hashtags.

| Museum | Followers | Activity Dates | Total Activity | Original Tweets | Most Used Hashtag /Function |
|--|-----------|-----------------------------|----------------|-----------------|---|
| Conjunto Monumental Alcazaba de Almería | 8640 | January-2020 to July-2020 | 30,694 | 2375 | #AlcazabaOnline 461Tweets/Educativo |
| ARQVA. Museo Nacional Arqueología Subacuática | 1510 | May-2018 to July-2020 | 481 | 391 | #Museo 31 Tweets/Informativo |
| Conjunto Arqueológico Baelo Claudia | 2399 | January-2015 to July-2020 | 1349 | 554 | #BaeloClaudia 58 Twees /Informativo |
| Conjunto Arqueológico Sitio de los dólmenes de Antequera | 1796 | Dicember-2015 to July-2020 | 4071 | 1451 | #SitiosdelosDólmenesde Antquera 388 Tweets/Informativo |
| Museu de Guissona (Camps i Cava) | 2858 | March-2015 to July-2020 | 4343 | 2431 | #Guissona 268 Tweets/Informativo |
| Libisosa Yacimiento arqueológico | 835 | May-2018 to July-2020 | 320 | 232 | #Libisosa 74 Tweets/Educativo |
| MARQ. Museo Arqueológico de Alicante | 18,116 | March-2019 to July-2020 | 18,261 | 2845 | #MARQ 817 Tweets/Informativo |
| Medina Azahara. Conjunto Arqueológico | 2238 | February-2016 to July-2020 | 3042 | 696 | #EnCasaConMedina 45 Tweets/Educativo |
| Museo Alhambra | 18,602 | March-2018 to July-2020 | 14,939 | 2291 | #MuseumWeek 87 Tweets/Educativo |
| MAC. Museu d' Arqueologia de Catalunya | 16,099 | May-2018 to July-2020 | 16,742 | 2801 | #MACbcn 256 Tweets/Informativo |
| Museo Arqueológico de Córdoba | 4960 | August-2018 to July-2020 | 6964 | 780 | #Prensa 84 Tweets/Informativo |
| Museo Arqueológico de Vizcaya | 1321 | February-2013 to July-2020 | 2269 | 1574 | #IceAgeEuropeNow 28 Tweets/Informativo |
| Museo Arqueológico de Granada | 2542 | October-2018 to July-2020 | 6968 | 1685 | #TesorosDelMusarqGranada 209 Tweets/Educativo |
| MAEF Museu. Museu Arqueol'gic d'Eivissa i Formentera | 498 | January-2013 to July-2020 | 561 | 526 | #viu_el_MAEF 45 Tweets/Informativo |
| MAN. Museo Arqueológico Nacional | 52,726 | Dicember-2017 to July-2020 | 16,029 | 3390 | #MANSiempreCerca 154 Tweets/Educativo |
| MUPREVA. Museo Prehistoria Valencia | 4508 | June-2016 to July-2020 | 5302 | 3147 | #Mupreva 253 Tweets/Informativo |
| Museo Canario | 3509 | September-2014 to July-2020 | 1827 | 1111 | #elmuseocanario 263 Tweets/Informativo |
| Museo de Altamira | 14,571 | January-2018 to July-2020 | 9317 | 916 | #cuevadeAltamira 88 Tweets/Informativo |
| Museo de la Evolución Humana | 36,192 | October-2017 to July-2020 | 16,209 | 1866 | #Burgos 141 Tweets/Informativo |
| Museo Íbero de Jaén | 3151 | November-2017 to July-2020 | 1631 | 997 | #MuseoIbero 106 Tweets/Informativo |
| MNAT. Museu Nacional Arqueològic de | 4083 | October-2012 to July-2020 | 2582 | 1437 | #joproposo 99 Tweets/Informativo |

| Tarragona | | | | | |
|---|--------|-----------------------------|--------|------|--|
| MNAR. Museo Nacional de Arte Romano | 19,153 | March-2011 to July-2020 | 2711 | 2197 | #LaCulturaEnTuCasa 53 Tweets/Educativo |
| Museu de Badaona | 4525 | October-2011 to July-2020 | 3116 | 2131 | #Badalona 394 Tweets/Informativo |
| Museu de la Noguera | 1010 | March-2013 to July-2020 | 1916 | 1279 | #Balaguer 140 Tweets/Informativo |
| Museu de Villena. Museo Arqueològic José María Soler | 1195 | August-2011 to July-2020 | 1224 | 971 | #Villena 298 Tweets/Informativo |
| Museu de la història i de la cultura de Mallorca. (Pollentia) | 5332 | June-2014 to July-2020 | 4362 | 2393 | #MuseudeMallorcaDesde casa 138 Tweets/Educativo |
| Museus de les Terres de l'Ebre i de la Mar de l'Ebre | 4715 | September-2019 to July-2020 | 5350 | 1921 | #terresdelebre 173 Tweets/Informativo |
| Oiasso. Museo Arqueològic Irún | 2325 | August-2015 to July-2020 | 4635 | 1904 | #Oiasso 238 Tweets/Informativo |
| Patronato Alhambra y Generalife | 64,520 | June-2018 to July-2017 | 21,802 | 2276 | #Alhambra 151 Tweets/Informativo |
| Vilamuseu. Red de Monumentos y Museos de Villajoyosa | 1904 | February-2012 to July-2020 | 2767 | 2112 | #Villajoyosa 540 Tweets/Informativo |
| Villa Romana La Olmeda | 1315 | April-2017 to July-2020 | 1787 | 1728 | #LaOlmeda 786 Tweets/Informativo |

Identifying the most frequently used hashtags provided a significant sample concerning what strategies institutions have used on Twitter. In general, communication was based in the sharing of daily information (upcoming events, hours of operation, etc.) with a generic hashtag for publicizing the museum's daily activities. This was the case with 23 (74.2%) of the most common hashtags analyzed in this study, compared with seven hashtags (23%) that sought to launch truly educational communication.

It is also noteworthy that the most frequent hashtags were those that were created during the lockdown, such as #EnCasaConMedina, #MANSiempreCerca, or #MuseudeMallorcaDesde casa, all of which will be analyzed in the final section of this study and which reflect an amplification and transformation of edu-communication on the web 2.0, thanks to the greater availability of time on the part of museum and site staff for designing and sharing content online [42].

3.2. Comparative Analysis of Activity during #MuseumWeek between 2018 and 2020

To learn whether there was a notable increase in publications during the confinement, the present study analyzed MuseumWeek (with hashtag #MuseumWeek), which is an initiative that is celebrated across five different continents, is linked to International Museum Day, and enjoys a significant following on social media [43]. The initiative was spearheaded by the Culture for Causes Network (CFCN) in 2014 and has the support of UNESCO and the Foundation CHANEL (among others). The event is important for museums and is held annually during the second week of May. This fixed schedule allowed us to compare the topics and hashtags used by different institutions on Twitter over the seven days of MuseumWeek (see Table 3). Spanish museums began to include MuseumWeek in their annual calendars in 2016. The data demonstrate that those institutions that decided to participate do so in a planned manner, generating different "threads" (strings of tweets that are published consecutively so that a user can surpass Twitter's limit on characters) about topics that the museum had settled on promoting.

Table 3. Topics for MuseumWeek 2020.

| Day | Hashtag | Definition | Main Objective |
|-----|------------------------|---|--------------------------|
| 1 | #HéroesMW | Pays tribute to workers in essential functions | Acknowledge |
| 2 | #CulturaEnCuarentenaMW | Invites users to recreate works of art from home | Participatory |
| 3 | #JuntosMW | Pays tribute to the larger community and collective effort. | Acknowledge/Reflective |
| 4 | #MomentosMuseoMW | Invites users to share memories from past visits. | Participatory |
| 5 | #climaMW | Tries to raise awareness about the climate crisis | Reflective |
| 6 | #TecnologíaMW | Shows how the institution uses technology to stay connected | Informative/Promotional |
| 7 | #SueñosMW | Invites users to dream of a better world | Reflective/Participatory |

During the 2020 event, which took place with the backdrop of the health crisis and the fact that a good portion of the planet was locked down at home, the chosen global theme was #togetherness. This choice was announced at the beginning of the year and, according to the official press release, sought to extend the mission of museums through online platforms in light of the challenges resulting from the health crisis [44]. In at least two of the seven proposals of #MuseumWeek, there was a call for users to share images (#MomentosMuseoMW and #CulturaEnCuarentenaMW). This final hashtag promoted an especially creative type of interaction: users were asked to use household objects to recreate works of art (following the previous proposal of the Getty Museum [45]) and had the biggest results. Among the other proposals ((#JuntosMW, #TecnologíaMW, #SueñosMW, and #HéroesMW), we ought to highlight the last one (#HéroesMW), since it engaged with the particular moment and context that overshadowed MuseumWeek, though it was not possible to observe any special significance of this hashtag for Spanish archaeological museums.

The analysis of the content of the tweets published during the last three years of #MuseumWeek by the institutions included in the present sample ($n = 31$) showed that not all museums participated in previous MuseumWeeks: 27 institutions did take part, though to different extents. Data confirm that lockdown conditions did not lead to a general increase in activity during MuseumWeek 2020 when compared to previous years (see Table 4).

Table 4. The participation of Spanish archaeological and open-air museums in MuseumWeek between 2018 and 2020.

| Museum | #MuseumWeek | | |
|--|--------------------------------|--------------------------------|-----------|
| | 2018 | 2019 | 2020 |
| Conjunto Monumental Alcazaba de Almería | Unrecoverable data | Unrecoverable data | 20 Tweets |
| ARQVA. Museo Nacional Arqueología Subacuática | There is no data | 10 Tweets | 6 Tweets |
| Conjunto Arqueológico Baelo Claudia | 16 Tweets | The museum did not participate | 13 Tweets |
| Conjunto Arqueológico Sitio de los dólmenes de Antequera | There is no data | 3 Tweets | 8 Tweets |
| Museu de Guissona (Camps i Cava) | 45 Tweets | 17 Tweets | 22 Tweets |
| Libisosa Yacimiento arqueológico | The museum did not participate | 1 Tweet | 2 Tweets |
| MARQ. Museo Arqueológico de Alicante | Unrecoverable data | 8 Tweets | 18 Tweets |
| Medina Azahara. Conjunto Arqueológico | There is no data | 5 Tweets | 8 Tweets |

| | | | |
|---|--------------------------------|--|----------------------------------|
| Museo Alhambra | 49 Tweets | 22 Tweets | 16 Tweets |
| MAC. Museu d'Arqueologia de Catalunya | Unrecoverable data | 3 Tweets | 11 Tweets |
| Museo Arqueológico de Vizcaya | Unrecoverable data | 15 Tweets (7 basque + 7 spanish + 1 english) | 14 Tweets (7 basque + 7 spanish) |
| Museo Arqueológico de Granada | Unrecoverable data | 2 Tweets (The museum did not participate) | 20 Tweets |
| MAEF Museu. Museu Arqueològic d'Eivissa i Formentera | The museum did not participate | The museum did not participate | 9 Tweets |
| MAN. Museo Arqueológico Nacional | 10 Tweets | 7 Tweets | 13 Tweets |
| MUPREVA. Museo Prehistoria Valencia | Unrecoverable data | Unrecoverable data | 29 Tweets |
| Museo Canario | 62 Tweets | 16 Tweets | 16 Tweets |
| Museo de Altamira | 4 Tweets | 7 Tweets | 21 Tweets |
| Museo de la Evolución Humana | Unrecoverable data | Unrecoverable data | 16 Tweets |
| Museo Íbero de Jaén | 8 Tweets | 14 Tweets | 9 Tweets |
| MNAT. Museu Nacional Arqueològic de Tarragona | Unrecoverable data | 9 Tweets | 21 Tweets |
| MNAR. Museo Nacional de Arte Romano | Unrecoverable data | 8 Tweets | 32 Tweets |
| Museu de Badalona | The museum did not participate | The museum did not participate | 10 Tweets |
| Museu de la Noguera | 10 Tweets (2 duplicates) | 10 Tweets | 8 Tweets |
| Museu de la història i de la cultura de Mallorca. (Pollentia) | 49 Tweets | 31 Tweets (2 tweets Mallorquí and 1 Tweet english) | 31 Tweets |
| Oiasso. Museo Arqueológico Irún | 12 Tweets | 21 Tweets | 7 Tweets |
| Vilamuseu. Red de Monumentos y Museos de Villajoyosa | 10 Tweets | 13 tweets | 11 Tweets |
| Villa Romana La Olmeda | 9 Tweets | The museum did not participate | 11 Tweets |

The activity of several institutions stands out in particular: the Museu de la història i de la cultura de Mallorca, the Museo de Prehistoria de Valencia (MUPREVA), and the Museo Nacional de Arte Romano (MNAR), all of which had on average more than four tweets a day. In the first two cases, Twitter activity resembled that of previous years (or data on previous activity was unavailable), whereas in the case of the Museo Nacional de Arte Romano, the data showed an increase in activity as a result of the closure of the physical museum.

The activity of the remaining institutions that have been examined was quite similar to that of previous years, demonstrating that for these museums the activity had been planned and prepared as part of the institution's annual social media strategy. Nevertheless, there are institutions that increased the number of published tweets (the Museo Arqueológico de Granada, the Museo de Altamira, and the Museo de Arqueología de Alicante (MARQ) or that participated in MuseumWeek for the first time (the Conjunto Arqueológico Baelo Claudia, the Museu Arqueològic d'Eivissa i Formentera (MAEF Museu), and the Museu de Badalona)

The reported numbers confirm that the Spanish archaeological and open-air museums that stand out for their constant and planned Twitter activity used MuseumWeek as a shared goal with the rest of the institutions that adapted the content of their collections to the topics and initiatives proposed by the larger organization. Furthermore, the health crisis made it possible for other

institutions that had previously not participated (or that had not participated in recent years) to join in on the initiative.

3.3. Analysis of Content Related to Edu-Communicative 2.0 Strategies

The second portion of this study, which is a fundamental aspect of our larger research trajectory, entailed analyzing the content of the tweets published during the lockdown in order to identify tweets whose content contained a predominantly educative purpose or theme. These tweets were then analyzed to detect the type of edu-communication that archaeological and open-air museums were publishing.

In this phase of research, the research tool designed for analyzing edu-communicative strategies was used (see Table 1). The detailed analysis of the tweets' content allowed us to determine the objective, r-elational factor, and type of interaction and ultimately learning that the institution sought to encourage among users. This analysis demonstrates the degree to which edu-communication is taking place and provides answers to the following questions: Was there a meaningful attempt to produce learning that went beyond the mere transmission of information? Was the r-elational factor present? Did museums partake in a process of patrimonialization, socialization, or symbolic identity formation through the use of archaeological heritage [46–48].

Table 5 lists the museums that used or created a hashtag in a planned way during the lockdown and also includes the 12 relevant hashtags from 10 different institutions. Additionally, the table includes the results of the classification of tweets according to variables V.1 (purpose of message), V.2 (r-elational factor and type of interaction encouraged among users), and V.3 (predominant learning theory of the proposals and messages), all of which were determined using the tool explained in Table 1.

Table 5. Analysis and catalogue of educational hashtags used during the lockdown.

| Museum | Hashtags Covid 19 | Tweets | V.1 Purpose of the Message | | | | | V.2 R-elational Factor | | | | V.3 Dominant Learning Type | | | | |
|---|--|--------|----------------------------|-------|------|-----|-------|------------------------|------|------|------|----------------------------|-------|------|------|------|
| | | | 1.1 | 1.2 | 1.3 | 1.4 | 1.5 | 2.1 | 2.2 | 2.3 | 2.4 | 3.1 | 3.2 | 3.3 | 3.4 | 3.5 |
| Conjunto Monumental Alcazaba de Almería | #TuAlcazabaOnLine #AlcazabaOnline | 461 | 191 | 153 | 2 | 72 | 43 | 109 | 22 | 18 | 312 | 104 | 157 | 48 | 4 | 148 |
| MARQ. Museo Arqueológico de Alicante | #quedateencasaconelMARQ | 181 | 105 | 2 | 0 | 1 | 73 | 0 | 0 | 0 | 181 | 0 | 94 | 2 | 1 | 84 |
| Medina Azahara. Conjunto Arqueológico | #EnCasaConMedina | 45 | 32 | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 45 | 0 | 45 | 0 | 0 | 0 |
| Museo Alhambra | #TuMuseoOnLine | 36 | 16 | 0 | 19 | 0 | 1 | 0 | 0 | 0 | 36 | 1 | 33 | 0 | 0 | 2 |
| Museo Arqueológico Córdoba | #QuedateEnCasa | 60 | 53 | 0 | 6 | 0 | 1 | 0 | 0 | 0 | 60 | 0 | 58 | 0 | 0 | 2 |
| Museo de Altamira | #AltamiraDesdeCasa | 30 | 12 | 12 | 3 | 2 | 1 | 6 | 0 | 6 | 18 | 7 | 12 | 4 | 0 | 7 |
| MAN. Museo Arqueológico Nacional | #MANSiempreCerca | 154 | 116 | 19 | 10 | 2 | 7 | 17 | 1 | 1 | 135 | 15 | 91 | 2 | 21 | 25 |
| MNAR. Museo Nacional de Arte Romano | #EnCasaconelMNAR #LaCulturaEnTuCasa | 53 | 33 | 12 | 2 | 1 | 5 | 0 | 0 | 14 | 39 | 0 | 37 | 4 | 3 | 9 |
| MNAT. Museu Nacional Arqueològic de Tarragona | #elMNATaCasa | 19 | 3 | 12 | 0 | 1 | 3 | 1 | 0 | 11 | 7 | 4 | 4 | 4 | 1 | 6 |
| Museu de la història i de la cultura de Mallorca. (Pollentia) | #MuseudeMallorcaDesdecasa | 138 | 110 | 0 | 23 | 1 | 4 | 0 | 0 | 0 | 138 | 0 | 98 | 0 | 37 | 3 |
| | | 1177 | 671 | 210 | 78 | 80 | 138 | 133 | 23 | 50 | 971 | 131 | 629 | 64 | 67 | 286 |
| | | % | 57 | 17.84 | 6.63 | 6.8 | 11.72 | 11.3 | 1.95 | 4.25 | 82.5 | 11.13 | 53.44 | 5.44 | 5.69 | 24.3 |

First of all, it merits mention that of the 31 museums included in the sample (i.e., those that had been deemed sufficiently active in a previous phase of research), only 10 (32.2%) launched an activity that was designed and planned during the lockdown. Among these 10, nearly all of them opted to adopt and adapt larger initiatives, such as the hashtag #LaCulturaEnTuCasa so as to include reference to a specific museum. This allowed an institution to differentiate itself from others, as we can see with the hashtags #AltamiraDesdeCasa from the Museo de Altamira or #eIMNATenCasa from the Museo Nacional de Arqueología de Tarragona.

The numerical data reveal different levels of activity among the studied institutions, with that of the Alcazaba de Almería towering over the rest with the use of the hashtags #TuAlcazabaOnline and #AlcazabaOnline 461 times within a span of 100 days. In a distant second and third place are the hashtags used by the Museo de Arqueología de Alicante (MARQ) (#quedateencasaconelMARQ) and the Museo Arqueológico Nacional, which marked some of its initiatives with the hashtag #MANSiempreCerca. Finally, the Museo de la historia i la cultura de Mallorca stands out with its hashtag #MuseudeMallorcaDesdeCasa, which was used a similar number of times to the previous two examples.

Regarding V.1 (“purpose of message”), a purely transmissive goal predominates: 739 of the 1177 analyzed tweets (68.2%) provided factual information about a collection. This purpose of transmitting information in a unidirectional manner is closely linked to the absence of the r-elational factor (i.e., the interaction between different users or between users and the institution). Participative and interactive proposals made up 17.84% of the total number of tweets. Next, the analysis found initiatives whose purpose was to promote enjoyment and transference (11.72%). Finally, the research showed that the least common purposes were promoting understanding (6.63%) and fostering values of conservation, protection, and respect (6.68%).

Turning to the second variable (“r-elational factor”), a high percentage of tweets (82.3%) did not display the r-elational factor that leads to the interaction between various users or between users and an institution. In addition, 11.3% displayed a behaviorist mode of interaction, whereas a mere 4.25% sought to promote co-creation through creative or collaborative proposals. Finally, only 1.95% led users to reflect or interpret through the use of questions or critical engagement.

With respect to variable 3 (“predominant type of learning”), 53.44% of the tweets employ a cognitivist approach to learning, while 11.13% were based on a more behaviorist approach that relied on questions and answers. Finally, connectivist (5.69%) and constructivist (5.44%) approaches were the least frequent. The remaining 24.3% did not pursue any explicit learning outcome. Among the use of these hashtags, not all the tweets were meant to showcase a particular piece from a collection, propose a shared reflection, or launch a collaborative project. In fact, of the total collection of analyzed tweets, there were 891 (75.8%) instances in which the audience could be expected to acquire some sort of knowledge.

When it comes to learning, the study identified educational strategies based in pedagogical theories ranging from behaviorism to connectivism. Among these, we can observe that the 10 museums that regularly used a new hashtag or adapted hashtags that were invented during the lockdown (e.g., #QuedateenCasa) published more educative tweets than messages that were purely informative or promotional.

Among the institutions studied in this paper, several stand out for having found a way to truly take advantage of edu-communicative processes online during the lockdown, thus marking a real shift in their approach to cultural action on social media. In the case of the Alcazaba de Almería, it was already possible to detect the institution’s interest in edu-communication, due to their high level of activity. This priority was not interrupted during the lockdown, since they published at least four tweets a day. Furthermore, even before the pandemic and health crisis, this institution already offered a wide range of educational initiatives (e.g., #TrivialAlcazabeño, sharing images, etc.). This helps explain how this institution had the most outstanding figures among the sampled institutions in terms of the three variables measured by the research tool. The Museo Arqueológico de Alicante (MARQ) stands out for its ability to transform their edu-communicative activities and adapt to changing circumstances: they published videos and tweets with images with accompanying texts

that explained a particular piece; furthermore, they even planned ceramic workshops or crafts activities that could be carried out at home and were inspired by a piece from their collection. The Museo Arqueológico Nacional (MAN) also increased their activity with the new hashtag #MANSiempreCerca. This activity included informative tweets, videos, and links to interactive activities hosted on the museum's website. Beyond this, MAN stood out in their deployment of edu-communicative initiatives during the lockdown, with activities being launched with the hashtags #RetoMAN and #InterpretaMAN. The first consisted in a challenge built around answering questions and constitutes an interesting behaviorist approach (i.e., based on stimulus and response) and presented users with new information in the form of text, images, links, etc. The second hashtag corresponds to a creative participation initiative in which the public recreated works from the collection using household items, drawings, photomontages, etc. Among the works that users were asked to represent were the Dama de Elche (27.03), the Bicha de Balazote (03.04) and the statuette of the goddess Isis (17.04). As a response to all the submissions that the museum received, they published a video on 12 May paying tribute to and thanking users for all the contributions. This project marked a turning point in so far as it sought to create and strengthen the links between a cybercommunity and the museum through an online edu-communicative initiative.

Although it published a smaller number of tweets, one of the museums that showed the greatest degree of adaptability in their use of social media during the lockdown was the Museo Nacional de Arte Romano (MNAR). During its nine years of Twitter activity, this institution has published a total of 2711 tweets (2197 containing original material created by the institution). That said, during the lockdown through the use of the hashtags #EnCasaconelMNAR and/or #LaCulturaentuCasa, MNAR launched some notable participatory activities including the following: "cocina como un romano," in which the museum provided recipes from Ancient Rome for users to try out at home and share online; the recreation of images using Playmobil; initiatives for the young users to depict the Olympic gods using templates posted online and common household items or short worksheets with 4–5 descriptive ideas. The Museo Nacional de Arqueología de Tarragona (MNAT) also rolled out similar activities that used craft projects to recreate pieces from the collection, cooking recipes, or proposals to share images online with other users (in this case, with the added bonus of giving away prizes from the museum as a way to boost participation). Other museums, such as the one from Altamira, opted not only to share content through video conferences, virtual visits, etc., but even shared at users' leisure activities in the form of word searches. Especially interesting was an activity based on the game "I spy" using prehistoric objects, all of which led to posts with images, texts and explanatory videos. This final project reflects the growing tendency to share cultural content with the youngest users during the lockdown and to provide activities that could even be used by formal educational institutions as part of online learning.

3.4. Analysis of Content Related to the Sustainable Development Goals

This research includes a partial analysis of the presence and potential of social networks, in this case Twitter, in the scope and awareness of sustainable development goals, given that the Spanish museum institutions that have opted for networks as an edu-communicative channel of heritage are offering within their possibilities a sustainable path that seeks to promote one of the most significant sustainable development goals in our field of work, Goal 4 "Quality Education", specifically promoting an inclusive, equitable, and quality education, promoting universal access learning opportunities [20] through participatory educational proposals that provide tools to work on museum content while posing creative challenges. This correspondence with the Sustainable Development Goals has been even more significant during the period of "state of alarm" experienced in the Spanish territory if we attend to the objectives proposed by the COVID-19 Global Education Coalition:

- Help countries in mobilizing resources and implementing innovative and context-appropriate solutions to provide education remotely, leveraging hi-tech, low-tech, and no-tech approaches;
- Seek equitable solutions and universal access.

- Ensure coordinated responses and avoid overlapping efforts.
- Facilitate the return of students to school when they reopen to avoid an upsurge in dropout rates.

Institutions are promoting distance education, saving cultural, social, and/or technological differences. Some, such as the Alcazaba de Almería, in the face of this situation, issued a tweet on a weekly basis, where they were accessible and motivating "we know that you are doing class work on our monuments, you can ask us what you want." Actions like this give us a glimpse that some institutions are truly promoting an edu-communication policy in line with the Sustainable Development Goals and its adaptation to the situation imposed by COVID 19, despite the limitations set by the digital divide.

On the other hand, museum institutions through their edu-communicative strategies are indicating about Goal 11: "sustainable cities and communities: Make cities inclusive, safe, resilient and sustainable" [21]. Specifically, this goal among its targets manifests the 11.4 "Strengthen efforts to protect and safeguard the world's cultural and natural heritage" directly linked to our research object. Museum institutions that have published tweets with a clear objective of appropriation and care of heritage (V.1 D.4 within the proposed analysis tool) are working to achieve this target.

Based on the content analysis carried out on the tweets, a frequency table has been developed that starts from the results obtained in the study variables (see Table 6); in this way, we first synthesize those referring to the dominant learning type in the message. These indicators are discriminated through five indicators (3.1 "Behaviorism", 3.2 "Cognitivism", 3.3 "Constructivism", 3.4 "Connectivism", and 3.5 "There is not"); these are related to Goal 4. Secondly, those referred to indicator 1.4 "Promotes values of ownership, protection and respect" within the variable purpose of the message (heritage education), which is the one referred to Goal 11.

Table 6. Analysis of content related to the Sustainable Development Goals.

| Nº Museum | Hashtags Covid 19 | Tweets | SGDs.4 Education | | | | | SGDs.11 Cities (Heritage) |
|--------------|----------------------|--------|-------------------|--------------|----------------|-----------------|---------------------|------------------------------|
| | | | 3.1 Beha v. | 3.2 Cogn. | 3.3 Constr. | 3.4 Connect. | 3.5 There is not | V1/D 1.4 owner.and resp. |
| 10 | 12 | 1177 | 131 | 629 | 64 | 67 | 286 | 80 |
| | | % | 11.13 | 53.44 | 5.44 | 5.69 | 24.3 | 6.8 |

Note. SGDs: Sustainable Development Goals.

After more than five years on average on Twitter, the most active Spanish archaeological and "site" museums on this social network, or at least those that seem to show an edu-communicative policy planned in the medium and long term, seem to have assumed the Sustainable Development Goals referring to education, as they have offered activities mainly of an educational nature over merely informing or advertising. Of the 1177 tweets analyzed for this last part of the study, 74.9% offer, through different strategies, educational content: from mostly cognitive proposals where the institution offers educational content without waiting or seeking the interaction of Internet users to initiatives of constructivist character where it is sought to promote a social construction of knowledge.

On the other hand, in the Sustainable Development Goal referring to the sustainability of cities, the goal referring to the care and respect of heritage (Goal 11.4) has not yet been truly assumed at a considerable level in terms of daily or weekly activity, given that only 6.8% of the tweets analyzed have been issued with a clear objective of appropriation and respect for heritage.

Finally, and in relation to the content analysis from the perspective of the Sustainable Development Objectives involved with quality education, the promotion of culture and the sustainability of heritage, despite the fact that they are not explicitly expressed in the sample analyzed, there is an interesting number of tweets that show a high presence of the processes of valuation, conservation, and care of the heritage attributed to its sustainability, usually when an

archaeological place has been damaged or is in danger. For example, Alcazaba de Almería tweeted 72 posts (15.62%) talking about heritage in danger, the importance of preservation work, etc. The rest of institutions, perhaps because they are indoor museums, barely tweeted about conservation or sustainability.

4. Discussion

On average, Spanish museums have been on social media for more than 5 years. Although the earliest profiles date to 2008, it was not until the period between 2012 and 2015 when one can really speak of a general presence on social media. The first years were characterized by the move from reliance on websites (a web 1.0 space) to social media (web 2.0 spaces) [13], which were seen as “spaces of convergence where the museum was the host but the public was able to feel as if they were at home” [49]. Nevertheless, there was a general sense of improvisation and a lack of a clear communicative program with concrete goals [27]. These beginnings are better described as communicative than as truly fostering dialogue [50]: museums with deeper pockets accumulated a greater number of followers and began short conversations with users or started to participate in debates that were not always begun by the museum itself [13], though some authors have maintained that the willingness to dialogue was not always open [50]. Yet this process of social opening slowly transitioned away from a rigid and informative mode of communication towards a significantly more open and inclusive sort of activity that encouraged participation and, importantly, has relied on a museum’s own identity to nurture a closer and more human type of relationship with users [49]. Several institutions have started to launch participatory projects that have attracted scholarly attention in Spain [26,51] and even further afield [52,53]. As we have already mentioned, all these processes are closely related to the sustainability of cultural heritage, therefore it is necessary to promote an education based on the objectives of sustainable development because they contribute to the comprehensive training of students and the development of skills. Key ideas contained in the 2030 agenda—“cultural awareness and expressions”, “digital competence”, and “social and civic”—underline the universal commitment to guarantee an inclusive, equitable, and quality education. Only by insisting and reinforcing its use in the educational context is it possible to achieve a cultural change based on sustainable development [54] and promote quality education based on social awareness and citizen commitment to heritage.

These events have undoubtedly sprung from the seeds of a cultural milieu on Twitter, which is clearly observable and, to a certain point, traceable through the use of different hashtags, such as #TwitterCultural (this provides a means of protecting things from the transitory nature of the platform). As a social media platform, Twitter makes it easy to find, talk about, and share whatever a user happens to be interested in and value. This has led to a fascinating dynamic whose evolution and the resulting processes of knowledge diffusion resemble, to a certain degree, the organization of an ant colony where an individual action (e.g., a like, retweet, or comment) forms part of the larger group identity located in cyberspace [55]. This shared identity can give rise to tightly knit heritage-based cybercommunities, when users come together due to an emotional connection to a piece of heritage [25,49,56]. Indeed, these communities can become extremely active when there is an activist mentality, as can be seen through the group “Huelva te Mira”, which was created in 2016 in response to the plundering of the archaeological site “La Orden-Seminario” (Huelva) and which boasts of more than 5000 followers on its official Facebook page. In this sense, we found on archaeological institutions’ social media two different contexts: on the one hand, museums and entities tasked with preservation, conservation as well as the study and sharing of heritage, and on the other hand, we can observe the museumization of sites where there is a perceived need to defend and demonstrate the value of local heritage by increasing heritage’s role in the process of identity formation; in the latter case, cybercommunities can emerge that are more participative [23] in line with the concept of cyber-citizenship [57].

The sudden arrival of COVID-19 has led to the physical closure of the museums. Yet in line with their own announcements, this closure has not only given way to increased activity on social media but has also allowed for the strategic organization of new ways to share an institution’s

collection or even show off its nooks and crannies. This has generated an opportunity to increase user interaction through national and international initiatives such as #LaCulturaEnCasa or to dedicate more resources to activities related to the annual #MuseumWeek project. The shuttering of museum buildings, however, has also shed light on the differences between different museums' use of social media and their capacity to move their activity into cyberspace. This study of Spanish archaeological and open-air museums demonstrates how informative modes of communication still predominate on Twitter when compared to edu-communication. That said, the importance of the latter has increased, representing 23% of used hashtags, compared to 74.2% of tweets in which already established generic hashtags are used to promote a museum's daily activity. This number reflects the communicative continuity discussed by other authors [13,27,49,50] but also shows that the lockdown has marked a shift in communicative strategies on social media, starting with proposals collected together with new hashtags during the lockdown. This forms part of a global trend seen in all types of museums, from the USA to Italy: we see the rise of virtual visits and guided content [58], as well as other activities that are more interactive and playful. These new tendencies have been spearheaded largely by art museums, rather than archaeological ones [45,59,60]. Museums have embraced Twitter not merely as a means to share information and promotional material, but also as a space for beginning meaningfully educative types of communication that are more intense and sustained (e.g., the average number of tweets from Italian museums has jumped from one to two a day [59]) and go hand-in-hand with an increased use of other digital platforms [61].

Since the lockdown in response to COVID-19 in Spain coincided with the already planned #MuseumWeek, which is the most important event for museums across the world on Twitter, it is especially fruitful to study museums' Twitter activity during #MuseumWeek 2020. This event began in 2014 at the initiative of French museums and was born from other previous projects, such as #Askacurator. The importance of the initiative was solidified when UNESCO got involved and it spread to other social media platforms. #MuseumWeek had already become the object of various studies that have sought to analyze the interactions, projects, and participation of museums in the said event through the use of messages published on social media [16,18,62]. These studies have presented similar findings that suggest that even if the lockdown did lead to a shift in the daily volume of messages online, #MuseumWeek in particular did not undergo such substantial changes. Although participation increased, that growth was constant with the continued rise of activity since #MuseumWeek began. In the context of this event, bidirectional communication between users and institutions or between different users remained rare or hardly relevant in terms of user responses, which had already been previously observed [63]. This suggests that education was a secondary objective for this initiative for which museum promotion and increasing visitor turnout were the primary goals. At any rate, this is the case for Spanish archaeological museums, even if the current social context is trending towards opening museums up to dialogue, actively involving the public, and listening to users' requests [16].

5. Conclusions

Over the last several years museums have changed their use of social media: from just posting publicity or basic information (e.g., hours of operation, prices, special events, etc.) towards a search to build communication based on the museum's own identity as an institution. In this regard, some museums have been leading the way for nearly a decade [49]. In other words, communication has evolved from the informative toward the participatory and inclusive [64], as can be seen in the present analysis of the most noteworthy examples of Spanish archaeological museums. Even though the present analysis has been limited to Twitter, it has been shown that there are indeed archaeological and open-air museums that have clearly opted for the model of the "social museum" or "museum 2.0" [65]. That said, it remains difficult to break with the predominant model of unidirectional communication that museums have used since they joined Twitter [13,14,64].

During the lockdown in response to COVID-19, Spanish archaeological museums have confirmed that they have received more traffic on their websites [42], as has been the case with other

museums internationally. What is most meaningful, however, is how Spanish archaeological and open-air museums have intensified their activity in 2.0 spaces and, even more importantly, have diversified the type of content that they offer. This constitutes an attempt to open up new, edu-communicative paths, even if the final objective in most cases is still limited to encouraging online traffic on their official websites and, to a lesser degree, participating in virtual visits that are either guided or self-directed.

It is possible that the lockdown has accelerated a process already begun by museums as 2.0 edu-communicative initiatives. In this case changing conditions and reduced mobility would have sped up a change in the way that institutions communicate and interact with users, thus giving rise to more participative projects on social media. This marks a clear shift in museum's conception of the web 2.0 and constitutes the first step towards building digital spaces for creation and encounters with users who feel that they are an active part of a museum and share the institutions objectives [24,66]; that is, the creation of heritage-based cybercommunities organized around a museum. Furthermore, this new educational space offers different ways of actively participating that ought to be explored and exploited to further learning [67]. In Spain, several apps have recently been launched such as RomanSites (<http://civitas.unizar.es>) or the Aragón open air museum [68] that are spearheading new ways of collaboratively cataloguing archaeological heritage and creating citizen science projects linked to heritage education. A participatory, collaborative, citizen science initiative that contributes to sustainability through non-invasive open-air musealization for the transmission and conservation of heritage.

In spite of the fact that the Sustainable Development Goals are not explicitly stated in the sample analyzed, there is a high presence of the processes of valorization, conservation, and care of heritage attributed to its sustainability (tweets highlight the importance of heritage, its processes of conservation, restoration, recovery of assets, transfers). Definitely, Sustainable Development Goals contribute to the comprehensive training of students and the development of the key competencies included in the 2030 agenda, underlining the universal commitment to guarantee an inclusive, equitable, and quality education [22,69]. However, we are aware of the limitations that social networks have in a significant part of the population, therefore they can facilitate access and reduce inequalities, but not in a totalitarian way as would be desirable, since it cannot overcome the existing digital divide. Although access to the Internet is not free or freely accessible at a universal level, it is access to the social network Twitter and/or opening a profile on this network. Therefore, any content or strategy with a marked educational character works to achieve a true education accessible to all the population to which they can have access. In some way, when the museum applies an edu-communicative strategy in its discourse, it is trying to overcome obstacles such as the economic one with the acquisition of tickets, or the accessibility to its space, avoiding travel to the physical place and bringing culture closer together, in addition to facilitating resources permanently available to the user.

To be aware, in figures of the social reach of these spaces, we refer to some data taken from The Social Media Family 2020, "Currently, 3.8 billion Internet users worldwide (of the 4.5 billion registered) interact on a social platform. To contextualize this data, use this comparison: 48% of the 7750 million inhabitants of the planet have a social profile" [70]. According to the latest Survey of Cultural Habits and Practices 2018–2019 prepared by the Ministry of Culture and Sports of Spain in September 2019 [71], in Spain there are 30,353,000 Internet users (76.9% of the population). Within these figures, 2,083,000 Internet users (5.3% of the total population: Internet users and non-Internet users) make virtual visits to museums, exhibitions, and monuments; 4,942,000 (12.5%) seek information on museums, exhibitions, and monuments.

We can even specify more: 2,408,000 Internet users (6.1% of the total population) "interact virtually through forums, messages, likes, social networks on issues related to culture" [71]. Within these figures, there is a very significant idea: the interaction linked to museums, libraries, and monuments in forums and social networks is barely 0.8% of the total population or 1.1% within Internet users. Even if we specify even more and only filter by "social networks", there are barely 280,000 Internet users (0.7% of the total population, 0.9% of the Internet population) who interact on

social networks from museums, libraries, and monuments. All these data prepared by the Government of Spain on cultural habits and practices show us the long way to go. Cultural networks and edu-communicative policy are exploring their interaction channels, causing important changes in relation to social reach, new opportunities, and educational models [72], which will undoubtedly be promoted with the current situation, immersed in a digital change. There is still a long way to go before we can talk about a cybercultural activity where institutions and heritage are the axis and motor of educational, transformative, and integrative dynamics, but this sustainability requires a paradigm shift in education from interactive and participatory environments [73]. Only through proper training in the field of formal education and the promotion and proliferation of truly participatory and inclusive initiatives, always from the free access and participation that the social network allows "knowledge as a shared resource" [74], will we be able to achieve the goals.

Finally, it is worth underscoring that this study has collected meaningful proposals and demonstrated that COVID-19 has been in some instances a sort of catalyst for the action taken by Spanish archaeological and open-air museums on social media. These institutions not only have increased their activity but have also published content with greater educational value. However, many institutions are still stuck in a model of unidirectional knowledge transmission, which is light years away from projects that are meaningfully rooted in constructivist and connectivist understandings of learning. This means that museums still need to move away from proposals that do not give rise to true edu-communicative initiatives: for all the exciting new proposals that we have seen, we cannot forget that only 12.2% of the 254 Spanish archaeological and open-air museums studied in this paper developed a edu-communicative 2.0 project on Twitter.

Author Contributions: Conceptualization, I.N.-N., P.R. and S.G.-C.; methodology, I.N.-N., S.G.-C., and B.A.; software, I.N.-N.; validation, P.R. and S.G.-C.; formal analysis, I.N.-N. and B.A.; investigation, I.N.-N. and B.A.; data curation, I.N.-N. and B.A.; writing—original draft preparation, I.N.-N. and S.G.-C.; writing—review and editing, P.R. and B.A.; visualization, S.G.-C.; supervision, P.R.; project administration, P.R.; funding acquisition, P.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Government of Aragón and European Regional Development Fund (ERDF), grant number RISS3-LMP18_18 "ARAGÓN OPEN AIR MUSEUM (2014-2020 Construyendo Europa desde Aragón)". Besides, this research was funded by the Spanish Ministry of Science, Innovation and Universities and EU's ERDF grant number EDU2016-78163-R "Educomunicación web 2.0 del patrimonio". Finally, this research was funded by Government of Aragón and the University institute for Research in Environmental Sciences of Aragon (IUCA) and Research Group ARGOS, grant number (S50_20R). The funders of this research have had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Acknowledgments: This article has been possible thanks to the project RISS3-LMP18_18 MUSEO AL LIBRE DE ARAGÓN (Government of Aragon and ERDF 2014-2020 "Building Europe from Aragon"), to the research project EDU2016-78163-R "Web 2.0 educommunication of heritage" (Ministry of Science, Innovation and Universities of Spain and ERDF), and the research group ARGOS, the didactics of social sciences, that has the support of the Government of Aragon, FEDER (EU) 2014-2020 and the University Institute of Research in Environmental Sciences of Aragon (IUCA) of the University of Zaragoza.

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

References

1. Ibañez-Etxeberria, Á.; Gómez-Carrasco, C.J.; Fontal, O.; García-Ceballos, S. Virtual Environments and Augmented Reality Applied to Heritage Education. An Evaluative Study. *Appl. Sci.* **2020**, *10*, 2352.
2. Aso, B.; García-Ceballos, S.; Rivero, P. La educomunicación web 2.0 de los museos en la sociedad digital. In *Re_Visiones sobre Arte, patrimonio y tecnología en la era digital*; Baldellou, F.C., Irala-Hortal, P., Eds.; Zaragoza: Gobierno de Aragón, Spain, 2019; pp. 339–345.
3. Chiappe, A.; Arias, V. La educomunicación en entornos digitales: Un análisis desde los intercambios de información. *Opción* **2016**, *32*, 461–479.
4. Narváez-Montoya, A. Educational communication, educommunication, and media education: A research and educational proposal from a culturalist approach. *Palabra Clave* **2019**, *22*, 22311.

5. Pineiro, V.; Igartua, J.J.; Rodríguez, I. Identity-related implications of the dissemination of cultural heritage through the Internet: A study based on Framing Theory. *Commun. Soc.* **2018**, *31*, 1–21.
6. Chng, K.S.; Narayanan, S. Culture and social identity in preserving cultural heritage: An experimental study. *Int. J. Soc. Econ.* **2017**, *44*, 1078–1091.
7. Feldman, J. Memorylands: Heritage and Identity in Europe Today. *Am. Ethnol.* **2017**, *44*, 143–185.
8. Enhuber, M. Art, space and technology: How the digitisation and digitalisation of art space affect the consumption of art—A critical approach. *Digit. Creat.* **2015**, *26*, 121–137.
9. Osuna, S.; López-Martínez, J. Educommunicative evaluation model in virtual education. *Opción Rev. Cienc. Hum. Soc.* **2015**, *31*, 832–853.
10. Pierroux, P.; Bäckström, M.; Brenna, B.; Gowlland, G.; Ween, G.B. Museums as Sites of Participatory Democracy and Design. In *A History of Participation in Museums and Archives. Traversing Citizen Science and Citizen Humanities*; Hetland, P., Pierroux, P., Esborg, L., Eds.; Routledge: London, UK, 2020; pp. 27–45.
11. Shehade, M.; Stylianou-Lambert, T. Virtual reality in museums: Exploring the experiences of museum professionals. *Appl. Sci.* **2020**, *10*, 4031.
12. Capriotti, P.; Losada-Díaz, J.C. Facebook as a dialogic communication tool at the most visited museums of the world. *Prof. Inf.* **2018**, *27*, 642–650.
13. Claes, F.; Deltell, L. Museos sociales. Perfiles museísticos en Twitter y Facebook 2012–2013. *Prof. Inf.* **2014**, *23*, 594–602.
14. Claes, F.; Deltell, L. Museo social en España: Redes sociales y webs de los museos estatales. *Prof. Inf.* **2019**, *28*, e280304.
15. Fletcher, A.; Lee, M.J. Current social media uses and evaluations in American museums. *Mus. Manag. Curatorship* **2012**, *27*, 505–521.
16. Pescarin, S.; Cerato, I.; Romi, P. Virtual museums and social networks. In Proceedings of the 2016 IEEE 2nd International Forum on Research and Technologies for Society and Industry Leveraging a Better Tomorrow, RTSI, Bologna, Italy, 7–9 September 2016; IEEE: Piscataway, NJ, USA, 2016.
17. Stuedahl, D.; Lowe, S. Social media as resource for involving young people in museum innovation: A cultural studies approach to co-design. *Int. J. Sociotechnology Knowl. Dev.* **2014**, *6*, 60–80.
18. Courtin, A.; Juanals, B.; Minel, J.L.; de Saint Léger, M. A tool-based methodology to analyze social network interactions in cultural fields: The use case "Museumweek". In *Social Informatics 2014. Workshops, Lecture Notes in Computer Science*; Aiello, L., McFarland, D., Eds.; Springer: Cham, Switzerland, 2015; Volume 8852, pp. 144–156.
19. Vrana, V.; Kydros, D.; Kehris, E.; Theocharidis, A.I.; Kavavasilis, G. Top Museums on Instagram: A Network Analysis. *Int. J. Comput. Methods Herit. Sci.* **2019**, *3*, 18–42.
20. Naciones Unidas. "Objetivo 4: Garantizar una Educación Inclusiva, Equitativa y de Calidad y Promover Oportunidades de Aprendizaje Durante toda la Vida para Todos" 2015. Available online: <https://www.un.org/sustainabledevelopment/es/education/> (accessed on 29 September 2020).
21. Naciones Unidas. "Objetivo 11: Lograr que las Ciudades Sean más Inclusivas, Seguras, Resilientes y Sostenibles", 2015. Available online: <https://www.un.org/sustainabledevelopment/es/cities/> (accessed on 29 September 2020).
22. UNESCO. Policy document on world heritage and sustainable development. In *The General Assembly of States Parties to the World Heritage Convention at Its 20th Session*; France 2015; pp. 1–18. Available online: <https://whc.unesco.org/en/sustainabledevelopment/> (accessed on 29 September 2020).
23. Navarro-Neri, I.; Rivero, P. "Los principales museos arqueológicos españoles en las redes sociales: Estudio exploratorio sobre procesos educomunicativos". *Ens. Rev. Fac. Educ. Albacete* **2019**, *34*, 163–178, doi:10.18239/ensayos.v34i1.2043.
24. Rivero, P.; Navarro-Neri, I.; Aso, B. Educommunication Web 2.0 for heritage: A view from Spanish museums. In *Handbook of Research on Citizenship and Heritage Education*; Delgado-Algarra, E.J., Cuenca-López, J.M., Eds.; IGI Global: Hershey, PA, USA, 2020; pp. 450–471.
25. Bauman, Z. *Los Retos de la Educación en la Modernidad Líquida*, 2nd ed.; Gedisa: Barcelona, Spain, 2009.
26. Cordón, D. Twitter como medio de comunicación para el Storytelling aplicado a la cultura: El caso de #Thyssen140. In *La Pantalla Insomne*; 2nd ed.; Universidad de la Laguna: Tenerife, Spain, 2015; pp. 2803–2823.
27. Gómez-Vílchez, S. Museos españoles y redes sociales. *Telos Cuad. Comun. Innovación* **2012**, *90*, 79–86.
28. Gómez-Vílchez, S. Debates culturales a través de Twitter. *Rev. PH* **2014**, *86*, 9–10.

29. González-Bouza, A.M. Estrategia de Comunicación Museística en Redes Sociales. El Caso de Santiago de Compostela. Ph.D. Thesis, Universidad de Santiago de Compostela, Santiago de Compostela, Spain, 2017.
30. Llerena-Iglesias, S. La Comunicación de los Museos Españoles en Twitter. Análisis de la Situación Establecimiento de Buenas Prácticas. Ph.D. Thesis, Universidad Carlos III de Madrid, Madrid, Spain, 2016.
31. Satta, F. Las Estrategias de Comunicación Digital de los Museos en las Redes Sociales. Análisis de Presencia y Rendimiento de los Museos de Arte Catalanes. Ph.D. Thesis, Universitat Rovira i Virgili, Cataluña, Spain, 2017.
32. Calaf, R.; Gillate, I.; Gutiérrez, S. Transitando por la Evaluación de los Programas Educativos de Museos de Arte del Proyecto ECPEME. *Educ. Siglo XXI* **2015**, *33*, 129–50.
33. Fontal, O. *La Educación Patrimonial. Teoría y Práctica en el Aula, el Museo e Internet*; Ediciones Trea: Gijón, Spain, 2003.
34. Kitungulu, L. Collaborating to Enliven Heritage Collections. *Mus. Int.* **2013**, *65*, 113–122.
35. Martín-Cáceres, M.; Cuenca, J.M. Educomunicación del patrimonio. *Educ. Siglo XXI* **2015**, *3*, 33–54.
36. Gabás, R. *Análisis de Actividad en Redes Sociales*, End-of-degree Project; Universidad de Zaragoza: Zaragoza, Spain, 2019 (unpublished).
37. Marta-Lazo, C.; Gabelas, J.A. *Comunicación Digital. Un Modelo Basado en el Factor Relacional*; Editorial UOC: Barcelona, Spain, 2016.
38. Marta-Lazo, C.; Marfil-Carmona, R.; Hergueta-Covacho, E. Aplicación de las Redes Sociales en el aprendizaje en conectividad: Uso del factor relacional en la dialéctica twitter. *Rev. Científica Electrónica Educ. Comun. Soc. Conoc.* **2016**, *16*, 2.
39. Siemens, G. Connectivism: A learning theory for the digital age. *Int. J. Instr. Technol. Distance Learn.* **2005**, 1–8.
40. Gabelas, J.A.; Marta-Lazo, C.; González-Aldea, P. El factor relacional en la convergencia mediática: Una propuesta emergente. *Anàlisi Quad. Comun. Cult.* **2015**, *53*, 20–34.
41. Escobar, J.; Cuervo, Á. Validez de contenido y juicio de expertos: Una aproximación a su utilización. *Av. Med.* **2008**, *6*, 27–36.
42. Museo Arqueológico Nacional. “Las redes sociales como protagonistas durante el confinamiento”. 2020. Available online: https://www.youtube.com/watch?v=VQf_zFN0LqY&t=140s (accessed on 7 September 2020).
43. Caerols-Mateo, R.; Viñarás-Abad, M.; González-Valles, J.E. Redes sociales y museos: Análisis de la campaña en Twitter para el Día Internacional de los Museos y Noche de los Museos. *Rev. Lat. Comun. Soc.* **2017**, *72*, 220–234.
44. Museum Week. Press Folder. 2020. Available online: <https://museum-week.org/wp-content/uploads/2020/05/Programme2020-Spanish.pdf> (accessed on 7 September 2020).
45. Poots, T. The J. Paul Getty Museum during the coronavirus crisis. *Mus. Manag. Curatorship* **2020**, *35*, 217–220.
46. Vicent, N.; Rivero, P.; Feliu, M. Arqueología y tecnologías digitales en Educación Patrimonial. *Educ. Siglo XXI* **2015**, *33*, 83–102.
47. Fontal, O.; Martínez-Rodríguez, M. La educación patrimonial como praxis pedagógica para la enseñanza de la arqueología. In: *Rescate: Del Registro Estratigráfico a la Sociedad del Conocimiento el Patrimonio Arqueológico como Agente de Desarrollo Sostenible*; Delgado, M., Vaquerizo, D., Ruiz, A.B., Eds.; Universidad de Córdoba: Córdoba, Argentina, 2017; pp. 141–153.
48. Rivero, P.; Fontal, O.; García-Ceballos, S.; Martínez-Rodríguez, M. Heritage Education in The Archaeological Sites. An Identity Approach in The Museum of Calatayud. *Curator Mus. J.* **2018**, *61*, 315–326.
49. Martínez-Sanz, R. Estrategia comunicativa digital en el museo. *Prof. Inf.* **2012**, *21*, 391–395.
50. Losada-Díaz, J.C.; Capriotti, P. La comunicación de los museos de arte en Facebook: Comparación entre las principales instituciones internacionales y españolas. *Palabra Clave* **2015**, *18*, 889–904.
51. Padilla-Meléndez, A.; Del Águila-Obra, A.R. Web and social media usage by museums: Online value creation. *Int. J. Inf. Manag.* **2013**, *33*, 892–898.
52. Suzić, B.; Karlíček, M.; Stříteský, V. Social Media Engagement of Berlin and Prague Museums. *J. Arts Manag. Law Soc.* **2016**, *46*, 73–87.

53. Zafiroopoulos, K.; Vrana, V.; Antoniadis, K. Use of twitter and Facebook by top European museums. *J. Tour. Herit. Serv. Mark.* **2015**, *1*, 16–24.
54. Dzimińska, M.; Fijalkowska, J.; Sulkowski, L. A conceptual model proposal: Universities as culture change agents for sustainable development. *Sustainability* **2020**, *12*, 4635, doi:10.3390/su12114635.
55. Forte, M.; Bonini, E. Embodiment and enaction: A theoretical overview for cybercommunities. In *Heritage in the Digital Era*; Ioannides, M., Addison, A., Georgopoulos, A., Kalisperis, L., Brown, A., Pitzalis, D., Eds.; Multi-Science Publishing Co.: Brentwood, UK, 2010; pp. 45–56.
56. Santacana, J.; Martínez-Gil, T. El patrimonio cultural y el sistema emocional: Un estado de la cuestión desde la didáctica. *Arbor* **2018**, *194*, 1–9.
57. Badillo, M.E.; Marta-Lazo, C. Ciberciudadanía a través de Twitter: Caso Gran Marcha Carnaval y consultas populares contra la minería en La Colosa. *Cuad. Info.* **2019**, *45*, 145–162.
58. Vassilakis, C.; Antoniou, A.; Lepouras, G.; Pouloupoulos, V.; Wallace, M.; Bampatzia, S.; Bourlakos, I. Stimulation of reflection and discussion in museum visits through the use of social media. *Soc. Netw. Anal. Min.* **2017**, *7*, 40.
59. Agostino, D.; Arnaboldi, M.; Lampis, A. Italian state museums during the COVID-19 crisis: From onsite closure to online openness. *Mus. Manag. Curatorship* **2020**, *35*, 362–372.
60. Zuanni, C. Italian Museums and Twitter: An analysis of Museum Week. *Archeostorie J. Public Archaeol.* **2017**, *1*, 119–133.
61. Orduña-Malea, E.; Font-Julián, C.I.; Ontalba-Ruipérez, J.A. Covid-19: Análisis métrico de vídeos y canales de comunicación en YouTube. *Prof. Inf.* **2020**, *29*, e290401.
62. Simeon, M.I.; Martone, A.; Cinquegrani, F. Digital communication in museums: An analysis of the museum week event. In Proceedings of the 20th IPSAPA/ISPALEM International Scientific Conference: The Erratic Behaviour of the Landscape-Cultural Mosaic: Emotion, Energy, Experience, Reggio Calabria, Italy, 7–8 July 2016; pp. 327–338.
63. Foucault, N.; Courtin, A. Automatic classification of tweets for analyzing communication behavior of museums. In Proceedings of the 10th International Conference on Language Resources and Evaluation, LREC, Portoroz, Slovenia, 23–28 May 2016; pp. 3006–3013.
64. Criado, J.I.; Villodre, J. Comunicando datos masivos del sector público local en redes sociales. Análisis de sentimiento en Twitter. *Prof. Inf.* **2018**, *27*, 614–623.
65. Simon, N. *The Participatory Museum*; Museum 2.0: San Jose, CA, USA, 2010; ISBN: 978 0615346502.
66. Fontal, O.; Ibáñez-Exteberria, A. Estrategias e instrumentos para la educación patrimonial en España. *Educ. Siglo XXI* **2015**, *33*, 15–32.
67. Pagano, A.; Palombini, A.; Bozzelli, G.; De Nino, M.; Cerato, I.; Ricciardi, S. ArkaeVision VR game: User experience research between real and virtual paestum. *Appl. Sci.* **2020**, *10*, 3182.
68. Biedermann, A.M. The diffusion of street art through different media: One app for the communication of the street art of Zaragoza. In Proceedings of the Fifteenth International Conference on Interdisciplinary Social Sciences – Virtual Conference. Athens, Greece, 20–22 July 2020.
69. UNESCO; UNICEF; The World Bank; UNFPA; UNDP; UN Women; UNHCR. Education 2030: Incheon Declaration and Framework for Action for the implementation of Sustainable Development Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. ED-2016/WS/28 W. In Proceedings of The World Education Forum 2015, Incheon, Korea, 19–22 May 2015. Available online: <https://unesdoc.unesco.org/ark:/48223/pf0000245656> (accessed on 16 September 2020).
70. The Social Media Family. *VI Estudio Sobre los Usuarios de Facebook, Twitter e Instagram en España*; Madrid 2020. Available online: <https://thesocialmediafamily.com/informe-redes-sociales/> (accessed on 28 September 2020).
71. Ministerio de Cultura y Deporte. *Encuesta de Hábitos y Prácticas Culturales 2018–2019*; Prepared by the Statistics and Studies Division, General Technical Secretariat, Ministry of Culture and Sports. Madrid, Spain, 2019. Available online: <https://www.culturaydeporte.gob.es/dam/jcr:1712f192-d59b-427d-bbe0-db0f3e9f716b/encuesta-de-habitos-y-practicas-culturales-2018-2019.pdf> (accessed on 28 September 2020).
72. Mora, H.; Pujol-López, F.A.; Mendoza-Tello, J.C.; Morales-Morales, M.R. An education-based approach for enabling the sustainable development gear. *Comput. Hum. Behav.* **2020**, *107*, 105775, doi:10.1016/j.chb.2018.11.004.

73. Egelund, J.; Hadgraft, R.; Kolmos, A.; Guerra, A. Strategies for education for sustainable development—Danish and Australian perspectives. *J. Clean. Prod.* **2016**, *112*, 3479–3491, doi:10.1016/j.jclepro.2015.09.063.
74. Kankovskaya, A.R. Higher Education for Sustainable Development: Challenges in Russia. *Procedia CIRP* **2016**, *48*, 449–453, doi:10.1016/j.procir.2016.03.153.



© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).