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Fostering Social Project Impact with Twitter: Current Usage and Perspectives

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Abstract: Social impact assessment has become a major concern within the research community. While different methodological advancements have been made to better display, as well as to measure, achieved impacts, social media has proved to be a potential domain to generate many new opportunities to support both the communication as well as the realization of social impact. Within this context, the current research presents an analysis of how Twitter is used among a subset of research projects to maximize social impact. The research focuses on the use of Twitter, as one of the most often used social media, by the members of scientific projects funded under one part of the FP7 funding framework of the European Union called Science in Society. The data were analyzed using NVivo, and WordStat Provalis software. The results presented in this study include exploratory data analysis, topic mining and the analysis of the impact of projects on Twitter. The results indicate moderate use of Twitter among the observed projects, but with a strong focus on the dissemination of project results, thus indicating a trend towards the usage of social media for communicating the social impact of research projects.

Keywords: social impact assessment; Twitter; topic mining; FP7; text mining

1. Introduction

1.1. Impact and Social Media

Impact evaluation has been at the center of research debate for less than a decade, and it is unlikely to go away any time soon, as the demand for such research continues to increase. In addition to the work of researchers, worldwide funding agencies are developing better monitoring and evaluation methodologies. European Framework Program Horizon 2020 (2014–2020) has identified impact as one of the three items to be evaluated in all research calls. The next Framework Program Horizon Europe (2012–2027) aims at maximizing impact research [1].

The debate about the limitations of measuring impact on the basis of academic citation dates back to the early 1990s [2] and it is commonly found in the literature that the impact evaluation of science cannot be limited to it. Academic citation is one of the measures, and recent developments include also the societal and policy impact, with innovative methodologies being tested and developed [3,4]. Furthermore, citation analysis has the academia as a key agent with influence to increase or decrease

the impact of a scientific contribution, and other agents such as stakeholders have a lack of possibilities to play a role in such citations. In this respect, it is important to mention the open access initiatives that promote access to scientific knowledge to all, which can include diverse kind of feedback from society to researchers. In this arena, Ravenscroft, Liakata, Clare and Duma [5] argued that the measure of impact must go beyond academic citations, and other information sources should be integrated. Considering the UK context, this team demonstrated that there is not a full correspondence between academic citations and achieved impact for researchers, and other data must be collected to ensure the adequate evaluation of the impact of science. Others have considered the requirements that are necessary to develop mixed methods [6] for evaluating impact—quantitative data are relevant; however, qualitative data are also needed, for instance, case studies [7]. Finally, another set of studies highlights that communication and dissemination activities addressed to policymakers and civil society are a preliminary step to achieving research impact because without including this step some research results may only be limited to a scientific audience [8]. Additionally, there are other methodologies designed to build predictive models that, for instance, predict the percentage of the possibility of obtaining success [9]. The IMPACT-EV team developed the SIOR portal by which a set of five indicators measure the social impact of research. Part of the same team developed novel methodologies oriented to capture citizens' inputs in social impact evaluation by means of the social impact in social media methodology (SISM) [10]. The SISM methodology opens up new venues not only for assessing the potential role of social media users but also for the researchers on how to make better use of these tools to showcase the achieved impact. This is precisely the aim of the present article.

Social networks all over the world play a relevant role in an increasing number of citizens' lives. The statistics show that the number of people using social media is increasing yearly. In 2019, 2.77 billion people were using social networks, and, according to Statista, by 2021, the number will reach 3.02 billion [11]. In the European Union, 65% of Internet users participate in social networks [12], while in the United States, 79% of the population have a social media profile [13]. In the research context, end-users play a fundamental role in the dissemination of research impact. As a result of this trend, the citation analysis which is mainly dominated by researchers, is being accompanied by interactions on social media from audiences beyond academia.

If dissemination, which is understood as social media usage, is properly conducted, the impact of research is extended to users of both academic and non-academic backgrounds [14], going beyond academic citations. Grande [15] concluded that social media such as Twitter could make knowledge transfer faster as Twitter users who are interested in a topic can obtain the information they need at the same time it is shared. In this way, other researchers and stakeholders may focus their attention on the improvement of strategies for driving impact in science [16]. This new path has established a different channel for research communities to transfer and communicate their work to those who are interested in their scientific findings [17]. Twitter can serve as the missing element that can be used to foster the impact of scientific findings and increase scientific information among non-scientific users [18]. For scientific projects to demonstrate their impact, researchers need tools such as Twitter to spread their impact [16] and to gather evidence of such impact to continue exploring impact beyond academic citations. For instance, Twitter is fundamental in the biomedical and social sciences fields in the spreading of research results [19,20]. In addition to their role of knowledge transference and information dissemination, social media can be a tool for the fostering of information dissemination [21].

1.2. Twitter Use for Driving Impact in Science

The previous literature has underscored that social media usage, in general, provides functional, social and hedonic benefits [22]. Parra-López et al. [22] proposed three hypotheses to analyze these benefits. According to hypothesis 1, using social media is beneficial for users as the information obtained from social media can be used for organizing and decision making; the example provided by authors is related to organizing and taking vacation trips. Along the same lines, hypothesis 3 highlighted that when users are motivated to use social media, they have the intention of basing

their organizing and decision making on such use. If users are encouraged to use social media when organizing and taking vacations trips, it follows that this same process could be transferred to the field of research. If scientists stimulate the sharing of evidence on social media, this evidence could be used by users for taking decisions based on science, promoting the impact of science. Exposure and reputation [23] were shown to motivate contributions in social media in this analysis. The participation of social media users in research, as the end-users and beneficiaries of research results, would be an excellent opportunity to drive impact in scientific projects. Involving researchers and social media users in science in search of open debate and active participation would transform research with effective strategies that enhance the social impact of social sciences and humanities research [24,25].

Social media users consider Twitter to be a useful tool for expressing their concerns in a wide variety of fields [26]. Among the different methods of analyzing what users share via social media, we find that top-down and bottom-up approaches [27] can determine what users describe as their daily concerns with the hashtags they use [28]. According to Cabré et al. [27], by comparing the results of both approaches, some new items are revealed. The current research and official social objectives leave some of the social needs out of the question. Far from being a negative aspect, this provides a unique opportunity for future research and scientific projects. As research end-users and social impact beneficiaries, society should be taken into consideration concerning the design of future scientific research.

Some examples have already been analyzed. In terms of health, patients use social media such as Facebook and Twitter to search for information, which affects the healthcare industry [29,30]. According to the results of Lander et al., only 2.2% of the physicians in the study had a professional Twitter account; however, given the relevance that families and patients gave to social media (as seen before, the statistics show that approximately 80% of the population in the US own a social media profile), they could benefit even more from the use of their professional Twitter pages to increase the scientific literacy rate among potential users or even to spread their collaborative actions with other physicians.

Some questions remain to be answered. Are all data tweeted evidence-based? Do users tweet or tag relevant, useful and beneficial information? Are all health professionals veridical? In 2012, 85% of Americans had access to the Internet [31], meaning that an increasing number of users have the possibility of surfing the Internet searching for some medical advice. This also increases the risk of obtaining false information. After an expert assessment, Alnemer et al. [32] found that only posts from physicians or official institutions were correct. To avoid obtaining misleading information, the authors identified four steps that would allow users to obtain trustworthy data: first, use hashtags related to the search, and then verify the number of followers, the activity and the interactions. Above all, if we wish to generate impact in science, all tweets must be supported by scientific evidence. This contribution is in line with other authors who highlight the relevance of participation and co-creation of knowledge [33] and dialogic evidence-based policies to achieve impact [34].

Among other uses of social media, Twitter can create communities around a specific discussion to improve communications among various actors such as patients, researchers and organizations. Users concerned or affected by the same health problem interact and use Twitter to this end. This is the case with the "Breast Cancer Social Media" Twitter support community (#BCSM). The impact provided by this group has demonstrated an 80.9% increment of overall knowledge about breast cancer including treatment options, generic testing and risk assessment, and a 67% decrease in the patients' anxiety before becoming members of the support group [35]. The American College of Radiology Twitter poll (#ACR2016) is a useful tool to obtain users' opinions about a session, a course or event, with the double aim of providing access and involving all stakeholders in the same discussion [36]. Finally, #MPNSM, "Myeloproliferative Neoplasms on Social Media", allows those affected to engage with care professionals. Gathering users' voices on Twitter can also provide new research opportunities for future innovation and research [37].

Although health issues constitute a large part of social media content, other authors have identified the necessity of increasing Twitter use in the social sciences and the humanities (SSH) to obtain evidence of impact in other fields [38]. In this particular study, the authors stress comparing the use of Twitter by the soft and hard sciences and found that whereas hard sciences use social media, blogs or podcasts, among others, no studies were emphasizing SSH communication using Twitter, and that when there was an exchange of information, it was revealed to be non-academic. It remains to be seen how SSH journals' use of Twitter can enhance the citation of academic research articles.

By performing an analysis of more than 1500 articles from different ecology journals, Peoples, Midway, Sackett, Lynch, and Cooney [39] concluded that Twitter was a significant tool that can predict citation rates: "Twitter activity was a more important predictor of citation rates than a 5-year journal impact factor". Additionally, this statement accentuates that, depending on the social media usage, articles in high-impact and low-impact journals can receive the same attention, contributing to advancing knowledge to expand the role of citation analysis. Nevertheless, even if they may seem to obtain the same results, the effects of traditional and alternative citations do not contribute equally. Being active on Twitter regarding an article does not mean that the article is cited by other academic works. It is indeed true that authors can be present on both social media and in scientific journals without excluding any. Along the same lines, authors who actively disseminate their research results observed how social media can, on one hand, offer a wider range of scenarios to share and promote their work with the scientific community and, on the other, with policymakers [40], providing them with information to enable future regulation modifications based on scientific evidence.

The abovementioned statistics confirm social media as the new tool to promote, disseminate and share knowledge and information from academia to non-academia and vice versa. The existing literature corroborates the benefits that society as a whole can gain from being active based on research results and the feedback of the citizenry.

This study aims to highlight how the use of Twitter can establish a positive and powerful impact in science, on multidirectional levels, among different science fields, among researchers and non-researchers or citizens, policymakers and academia. We analyze how a subset of EU-funded projects are using social media to showcase and update the achieved impact. In doing so, the methodology used is described, including the findings of the selected projects' sample. Four layers of analysis are presented to fully determine the different current usages. Examples of how social media can be used to increase the impact of scientific projects are provided. Twitter becomes an important tool that facilitates these multidirectional exchanges in the precise moment when users trust tweets to be a signal of academic and non-academic impact [41]. Twitter also proves to be an instrument that can measure what users think of scientific articles and the impact of science by complementing traditional and modern or alternative citations metrics [42]. All of the collected evidence indicates the relevance of Twitter use for monitoring or measuring the impact of scientific projects. The article closes with a discussion and some concluding remarks on how to enhance the use of social media to promote the social impact of science.

2. Materials and Methods

It is a well-known fact that research and innovation influence and contribute to the level of well-being and prosperity of both individuals and society in general. Moreover, research and innovation, as well as knowledge and education, are the prerequisites for creating jobs and obtaining citizens' satisfaction in the long term. Therefore, the European Union is investing a great proportion of its budget towards funding various scientific projects from all areas of science.

One of the frameworks under which the European Union is funding scientific projects is the FP7, which was designed as an answer to issues about employment needs, competitiveness and the quality of life in Europe [43]. FP7 stands for the Seventh Framework Programme for Research and Technological Development, which was the main instrument for funding research in Europe from 2007 until 2013 [43]. The FP7 is legally based on Decision No. 1982/2006/EC of the European Parliament and

of the Council of 18 December 2006 concerning the Seventh Framework Programme of the European Community for Research, Technological Development and Demonstration Activities (2007–2013). The Decision states that the aim of the FP7 framework is "to contribute to the Union becoming the world's leading research area" [44] (p. 1). Moreover, it has been stated that FP7 is supposed to have a strong focus on promotion and investment in excellent state-of-the-art research [44]. To meet the objectives of the FP7 stated by the Decision, four types of activities have been identified as those that must be promoted by the FP7 programmes; hence, four programmes have been established:

1. the Cooperation programme—focused on transnational cooperation on policy-defined themes,
2. the Ideas programme—focused on investigator-driven research based on the initiative of the research community,
3. the People programme—focused on support for individual researchers and
4. the Capacities programme—focused on support for research capacities [44].

In addition to the named programmes, the FP7 also supported the Joint Research Centre as scientific and technical support for policies of the European Union, as well as the Euroatom programme for nuclear research [44].

For this study, a focus has been placed on the Science in Society part of the FP7 Capacities Programme. According to the abovementioned Decision, the objective of the Science in Society part of the framework is "to stimulate, to build an open, effective and democratic European knowledge-based society, the harmonious integration of scientific and technological endeavor, and associated research policies in the European social web, by encouraging pan-European reflection and debate on science and technology and their relationship with the whole spectrum of society and culture" [44] (p. 34). Furthermore, the Science in Society work programme states that Science in Society "acts on the relations between societal actors involved in the research and innovation process, providing them with an adequate framework for their engagement in the future Societal Challenges" [45] (p. 6).

This paper analyses the use of social networks for fostering project impact, with a special focus on the analysis of the Twitter accounts and activities of such networks. To evaluate the potential of Twitter use in fostering project impact, we have decided to focus on the Science in Society FP7 projects funded by the European Union. One of the limitations of this study is that in the beginning of the FP7 projects the use of Twitter in research projects was not as popular as it is now and there are projects that are not included in the analysis because they did not use it for this reason.

To meet the goals of this paper and for this research, the Community Research and Development Information Service (CORDIS) was used for identifying the Science in Society projects. CORDIS is the primary public repository and portal for information dissemination on all research projects funded by the European Union [46]. Using CORDIS, overall, 181 projects were identified for participation in this study. All of the projects had been completed at the time of the observation and analysis for this study.

Table 1 presents the descriptive statistics for the project duration and project funding for 181 observed Science in Society FP7 projects. According to the analysis and Table 1, the minimum duration of the observed projects is 6 months, while the maximum is 63 months. Observing the means, the average duration of the Science in Society FP7 projects is 33.17 months, with a standard deviation of 11.37.

Table 1. Project duration descriptive statistics.

	N	Minimum	Maximum	Mean	Standard Deviation
Project duration	181	6	63	33.17	11.37

2.1. Data Extraction

The data extraction for this study was conducted in August and September of 2017. Social media accounts of the Science in Society FP7 project were identified by searching several social networks,

namely, Twitter, YouTube, Facebook and LinkedIn. After the initial search, all social media accounts of the observed Science in Society FP7 projects were extracted and analyzed. Next, the focus was on Twitter social network use. For further data extraction and detailed analysis of the Twitter accounts and tweets of the observed Science in Society FP7 projects, the qualitative data analysis software NVivo, version 11 (Alfasoft, Göteborg, Sweden) and the text analysis software WordStat Provalis, version 7 (Provalis Research, Montreal, QC, Canada) were used.

NVIVO has an option to extract information from selected Twitter accounts. The information was organized as follows: the extraction of each Twitter account contains the following information: the first sheet collects tweets produced by the project Twitter account, and the second one collects tweets from other accounts retweeted by the project Twitter account. Thus, the first sheet contains tweets originally produced by the project to conduct content analysis. Additionally, the collected tweets were organized by the number of retweets received to determine which type of content obtained more attention from users. Finally, the extraction of the hashtags used could be useful to generate keywords and to analyze the tweets from the Twitter project account. The "mentions" are useful to determine which accounts are identified in the tweets.

2.2. Data Analysis

The data analysis for this study was conducted in four phases: (i) analysis of social media usage for the Science in Society FP7 projects, (ii) exploratory data analysis of the tweets, (iii) topic mining analysis, and (iv) analysis of the impact of the projects on Twitter.

2.2.1. Use of Social Media

After the search of Facebook, Twitter, LinkedIn and YouTube as the four selected social networks and the identification of the social media accounts of the Science in Society FP7 projects, the analysis of the social media usage for the observed projects was conducted. First, basic descriptive statistics were employed, calculating the frequencies and percentages of social media accounts based on the selected social networks. Second, a Spearman's correlation analysis of the social media usage for Science in Society FP7 projects was conducted.

2.2.2. Exploratory Data Analysis

For exploratory data analysis, the text analysis software WordStat Provalis was used. First, the 50 most frequently used words in tweets were identified and extracted by using the word extraction approach. This approach was employed to detect the most frequently used words in tweets of the Science in Society FP7 projects. Second, the proximity plot based on tweets that mention the most-used word in tweets was created using the WordStat Provalis software. The proximity plot is the data visualization chart that shows the distance between a most-used word and other observed words, whereby the words that frequently tend to occur near the selected word are shown at the top of the chart [47]. According to Provalis Research, the proximity plot is "the most accurate way to graphically represent the distance between objects by displaying the measured from one or several target objects to all other objects." [47] (p. 80). The proximity plot is used in the present study to identify the words that co-occur with one word that is used the most often in the tweets of the observed projects.

2.2.3. Topic Mining

Topic mining analysis was also conducted using the WordStat Provalis software. First, the tweet topics were mapped. Second, the analysis of the tweet topics was conducted, revealing the eigenvalues, percentage of variances, frequencies and the number and percentage of cases for each topic and its keywords, also providing examples of the tweets for each of the topics. The topic mining approach was used to identify the topics that emerge the most often in tweets of the Science in Society FP7 projects. After the extraction of the topics based on the factor analysis, cluster analysis of the extracted topic was

conducted to investigate the topics that occur together. A topic map was created based on the results of the cluster analysis.

2.2.4. Impact of Projects on Twitter

The analysis of the impact of Science in Society FP7 projects on Twitter was based on Twitter statistics, calculating the basic descriptive statistics of tweets and retweets, followers and following accounts every month and for the entire duration of the observed projects. Moreover, the tweet statistics were calculated and analyzed in terms of the topics. Besides, the tweets with the largest number of retweets were extracted and analyzed. Finally, a Spearman's correlation analysis of tweet impact indicators was conducted

3. Results

This section of the paper presents the results of the previously described data analysis regarding the social media usage for the observed Science in Society FP7 projects, exploratory data analysis of the tweets, analysis based on the topic mining of the tweets and the analysis of the impact of Science in Society FP7 projects on Twitter.

3.1. Use of Social Media

The use of social media within the Science in Society FP7 projects is presented in Tables 2 and 3. For this analysis, the focus was on Twitter, Facebook, LinkedIn and YouTube. The results of the percentage of Science in Society FP7 projects that use social media (Twitter, Facebook, LinkedIn and YouTube) are presented by Table 2. Out of 181 projects, fewer than a half of them (30.4%) have Twitter accounts, whereas a minority (7.7%) have LinkedIn accounts. A total of 19.9% of the observed projects have YouTube accounts, whereas 26.5% of them have Facebook accounts.

Table 2. Usage of social media for Science in Society FP7 projects (N = 181 projects).

Social Media Account	Number of Projects	%
Twitter account	55	30.4%
Facebook account	48	26.5%
LinkedIn account	14	7.7%
YouTube account	36	19.9%

Table 3. Spearman's correlation analysis of the usage of social media for Science in Society FP7 projects (N = 181 projects).

Social Media Account	Twitter	Facebook	LinkedIn	YouTube
Twitter	1	0.474 **	0.303 **	0.393 **
Facebook		1	0.341 **	0.516 **
LinkedIn			1	0.322 **
YouTube				1

** Correlation is significant at the 0.01 level (2-tailed).

Table 3 presents the results of the Spearman's correlation analysis of the social media usage for the Science in Society FP7 projects. All the presented correlations are significant at the 1% level. The highest positive correlation among the observed social media accounts is visible between Facebook and YouTube accounts, which means that the projects that have Facebook accounts are more likely to also have YouTube accounts and vice versa.

3.2. Exploratory Data Analysis

Table 4 presents the frequencies of the 50 most-used words in tweets of the Science in Society FP7 projects. As shown in Table 4, the most-used word is "science" with a frequency of 2246 times used in

the Science in Society FP7 projects' tweets. Other words in the top 5 most-used words in tweets are "gender", "RRI", "conference" and "project".

Table 4. Frequency of the 50 most-used words in tweets.

Extracted Words	Frequency	% Shown	% Processed	% Total
SCIENCE	2246	4.45%	1.10%	0.51%
GENDER	1392	2.76%	0.68%	0.32%
RRI	1224	2.42%	0.60%	0.28%
CONFERENCE	981	1.94%	0.48%	0.22%
PROJECT	915	1.81%	0.45%	0.21%
WOMEN	777	1.54%	0.38%	0.18%
INNOVATION	710	1.41%	0.35%	0.16%
POLICY	668	1.32%	0.33%	0.15%
GREAT	664	1.32%	0.32%	0.15%
THANKS	623	1.23%	0.30%	0.14%
WORKSHOP	603	1.19%	0.29%	0.14%
OPENACCESS	599	1.19%	0.29%	0.14%
OPENSCIENCE	567	1.12%	0.28%	0.13%
CHECK	566	1.12%	0.28%	0.13%
NEWS	542	1.07%	0.26%	0.12%
SCIENTISTS	502	0.99%	0.25%	0.11%
STEM	495	0.98%	0.24%	0.11%
READ	485	0.96%	0.24%	0.11%
ACCESS	437	0.87%	0.21%	0.10%
JOIN	417	0.83%	0.20%	0.10%
FOLLOW	406	0.80%	0.20%	0.09%
EDUCATION	403	0.80%	0.20%	0.09%
REPORT	397	0.79%	0.19%	0.09%
BLOG	386	0.76%	0.19%	0.09%
VIDEO	381	0.75%	0.19%	0.09%
EVENT	373	0.74%	0.18%	0.09%
FUTURE	372	0.74%	0.18%	0.09%
SOCIETY	369	0.73%	0.18%	0.08%
DAY	365	0.72%	0.18%	0.08%
UK	356	0.71%	0.17%	0.08%
FACEBOOK	351	0.70%	0.17%	0.08%
FISH	350	0.69%	0.17%	0.08%
TEACHERS	348	0.69%	0.17%	0.08%
EQUALITY	337	0.67%	0.16%	0.08%
SOCIAL	337	0.67%	0.16%	0.08%
FISHING	326	0.65%	0.16%	0.07%
PEOPLE	326	0.65%	0.16%	0.07%
UNIVERSITY	313	0.62%	0.15%	0.07%
INTERNATIONAL	304	0.60%	0.15%	0.07%
WEEK	303	0.60%	0.15%	0.07%
PUBLIC	302	0.60%	0.15%	0.07%
WORLD	301	0.60%	0.15%	0.07%
MEETING	294	0.58%	0.14%	0.07%
TIME	291	0.58%	0.14%	0.07%
TRAINING	289	0.57%	0.14%	0.07%
SCIENCEMEDIA	288	0.57%	0.14%	0.07%
SCIENTIFIC	287	0.57%	0.14%	0.07%
HEALTH	285	0.56%	0.14%	0.07%
CHANGE	284	0.56%	0.14%	0.06%
RESEARCHERS	284	0.56%	0.14%	0.06%

Figure 1 presents the proximity plot based on tweets that mention the word "science". The presented proximity plot reveals which words occur most frequently with the word "science"

as the one used in Science in Society FP7 projects' tweets most often according to the exploratory data analysis presented above. As shown in Figure 2, the words "gender", "women", "society", "innovation" and "education" are used the most frequently along with the observed word "science".

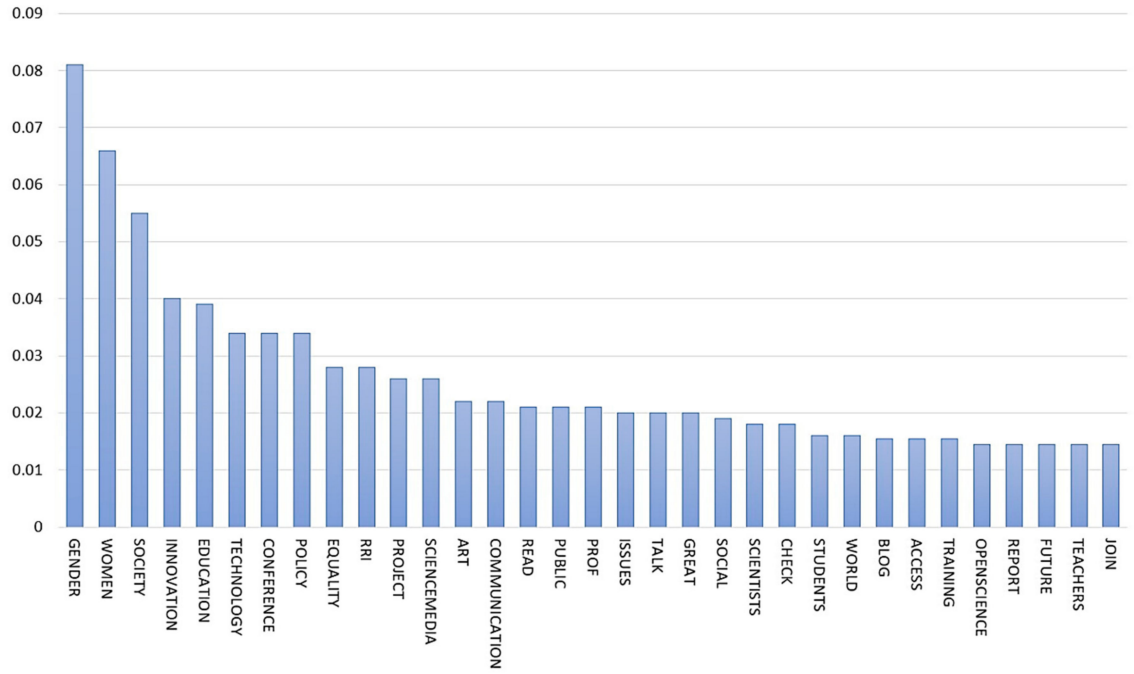

Figure 1. Proximity plot based on tweets that mention the word "science".

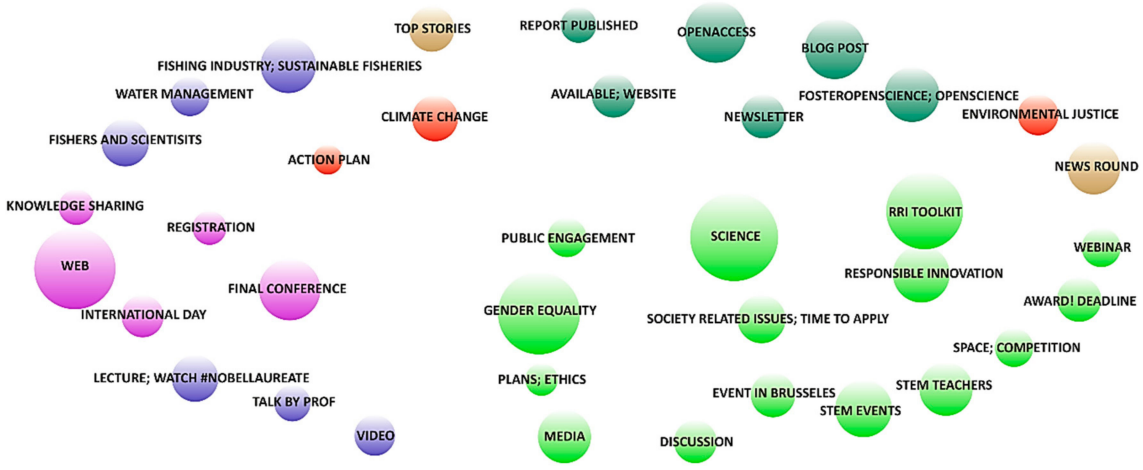

Figure 2. Topic mapping of tweets.

3.3. Topic Mining

Figure 2 presents the topic map of Science in Society FP7 projects' tweets based on the topic mining and cluster analysis of the extracted topics. As shown in Figure 2, there is a total of 7 groups of topics present on the map where each group is color-coded. The size of the circle representing each of the topics is proportional to the frequency and the number of cases in which a certain topic is present. Overall, 40 topics are identified and presented on the topic map.

The identification of the topics in Science in Society FP7 projects' tweets, showing the eigenvalues, percentage of variances, frequencies and the number and percentage of cases for each topic and its keywords are presented in Table 5. The topics shown in Table 5 are grouped based on the cluster analysis of the topics and the topic mapping shown in Figure 2.

Table 5. Identification of topics in tweets.

No	Name	Keywords	Eigen-Value	% Var	Freq	Cases	% Of Cases
		Group 1					
1	WEB	WEB; FACEBOOK; FOLLOW; THANKS	2.41	1.25	1607	1007	4.14%
2	KNOWLEDGE SHARING	SHARING; KNOWLEDGE; INFORMATION	1.15	0.59	537	507	2.09%
3	INTERNATIONAL DAY	DAY; INTERNATIONAL; MEETING	1.12	0.58	938	882	3.63%
4	REGISTRATION	REGISTRATION; HELP; LINK	1.12	0.57	465	443	1.82%
5	FINAL CONFERENCE	CONFERENCE; FINAL	1.41	0.65	1147	1047	4.31%
		Group 2					
6	CLIMATE CHANGE	CLIMATE; CHANGE	3.03	0.74	520	390	1.60%
7	ENVIRONMENTAL JUSTICE	JUSTICE; ENVIRONMENTAL	1.56	0.77	355	255	1.05%
8	ACTION PLAN	ACTION; PLAN	1.2	0.58	253	236	0.97%
		Group 3					
9	NEWS ROUND	NEWS; ROUND; STORIES	1.4	0.76	726	586	2.41%
10	TOP STORIES	TOP; DAILY; STORIES	1.78	0.82	589	458	1.88%
		Group 4					
11	LECTURE; WATCH #NOBELLAUREATE	LECTURE; NOBELLAUREATE; WATCH; NOBEL	1.62	0.78	786	613	2.52%
12	TALK BY PROF	TALK; PROF	1.2	0.6	424	386	1.59%
13	VIDEO	VIDEO; YOUTUBE	1.28	0.63	493	453	1.86%
		Group 5					
14	WATER MANAGEMENT	MANAGEMENT; WATER	1.3	0.63	406	406	1.67%
15	FISHING INDUSTRY; SUSTAINABLE FISHERIES	FISHING; FISHERIES; FISH; SUSTAINABLE; INDUSTRY	1.52	0.74	1328	1124	4.62%
16	FISHERS AND SCIENTISTS	SCIENTISTS; FISHERS; FISHERMEN	1.14	0.6	763	693	2.85%
		Group 6					
17	BLOG POST	BLOG; POST; READ; EXCHANGE	1.44	0.72	1273	1036	4.26%
18	REPORT PUBLISHED	REPORT; PUBLISHED	1.13	0.59	506	490	2.02%
19	OPEN ACCESS	OPENACCESS; POLICIES; ACCESS	1.43	0.69	1212	1029	4.23%
20	FOSTEROPENSCIENCE; OPENSCIENCE	FOSTER OPEN SCIENCE; OPEN SCIENCE; OPEN DATA; TRAINING; HORIZON	1.25	0.67	1264	1092	4.49%
21	AVAILABLE; WEBSITE	AVAILABLE; WEBSITE; ONLINE; PROGRAMME	1.24	0.61	885	797	3.28%
22	NEWSLETTER	NEWSLETTER; ISSUE; POLICY	1.17	0.59	984	950	3.91%
		Group 7					
23	RRI TOOLKIT	RRI; TOOLKIT; RRITOOLS	1.67	0.75	1511	1239	5.10%
24	STEM EVENTS	EVENTS; DISCOVER; STEM; EVENT	1.61	0.72	1128	977	4.02%
25	AWARD! DEADLINE	DEADLINE; AWARD; PRACTICE; EDITION; APPLY	1.56	0.76	627	530	2.18%
26	MEDIA	MEDIA; SCIENCEMEDIA; SOCIAL	1.5	0.75	803	645	2.65%
27	GENDER EQUALITY	GENDER; EQUALITY	1.47	0.75	1626	1334	5.49%

Table 5. *Cont.*

No	Name	Keywords	Eigen-Value	% Var	Freq	Cases	% Of Cases
28	COUNTRY	COUNTRY; PRIZE; CONTESTANT	1.46	0.72	368	306	1.26%
29	STEM TEACHERS	TEACHERS; SCHOOL; STUDENTS; STEM	1.34	0.66	835	764	3.14%
30	SOCIETY RELATED ISSUES; TIME TO APPLY	ISSUES; SOCIETY; APPLY; TIME	1.29	0.63	816	768	3.16%
31	DISCUSSION	DISCUSSION; PANEL; JOIN	1.27	0.63	734	670	2.76%
32	PUBLIC ENGAGEMENT	ENGAGEMENT; PUBLIC; ENGAGE	1.26	0.64	587	528	2.17%
33	RESPONSIBLE INNOVATION	INNOVATION; RESPONSIBLE	1.23	0.69	890	751	3.09%
34	CHILDREN	CHILDREN; UNIVERSITIES; UNIVERSITY	1.23	0.61	579	528	2.17%
35	CAREER RESEARCHERS	CAREER; RESEARCHERS; FEMALE	1.17	0.59	503	467	1.92%
36	WEBINAR	WEBINAR; REGISTER; MISS	1.17	0.62	459	418	1.72%
37	EVENT IN BRUSSELS	BRUSSELS; TAKING; COMPETITION; EVENT	1.16	0.63	478	449	1.85%
38	SPACE; COMPETITION	SPACE; COMPETITION; RESOURCES; TEACHING	1.16	0.62	486	459	1.89%
39	PLANS; ETHICS	PLANS; ETHICS; ROLE	1.13	0.59	454	427	1.76%
40	SCIENCE	SCIENCE; TECHNOLOGY	1.13	0.62	2305	2229	9.17%

Within the first group, the largest eigenvalue (2.41), as well as the highest frequency (1607), belongs to the topic of Web, which contains the keywords "web", "Facebook", "follow" and "thanks". However, when considering the number of cases, the topic Final Conference is mentioned in the highest number of cases (1047) among the first group of topics. In the second group of topics, the largest eigenvalue (3.03), as well as the highest frequency (520) and the highest number of cases (390), is shown for the topic Climate Change. Out of the two topics present in the third group, the topic of Top Stories, containing the keywords "top", "daily" and "stories", has the greater eigenvalue (1.78), while the topic News Round has the higher frequency of 726 in 586 cases. Within the fourth group of topics, the topic Lecture; Watch #Nobellaureate has the largest eigenvalue (1.62), as well as the highest frequency (786) and the highest number of cases (613). The topic Fishing Industry; Sustainable Fisheries has the largest eigenvalue (1.52), the highest frequency (1328) and the highest number of cases (1124) among the topics of the fifth group. In the sixth group, the largest eigenvalue (1.44), as well as the highest frequency, belongs to the topic Blog Post, while the highest number of cases is for with the topic Fosteropenscience; Openscience (1029). The last, seventh, group of topics contains the most extracted topics. In this group, the largest eigenvalue (1.67) is visible with the topic RRI Toolkit containing the keywords "RRI", "Toolkit" and "RRItools". However, the highest frequency (2305), as well as the highest number of cases (2229), belongs to the topic of Science, which contains the keywords "science" and "technology".

When considering the overall results, the highest frequency mentions in the Science in Society FP7 projects' tweets is obtained by the topic Science with a frequency of 2305 in 2229 cases, which amounts to 9.17% of all observed cases. However, the largest eigenvalue of 3.03 in the overall results is obtained by the Climate Change topic.

Whereas Table 5 presents the analysis of the topics of the Science in Society FP7 projects' tweets, Table 6 presents examples of tweets for each of the identified and extracted topics.

Table 6. Example tweets per topics.

No	Name	Example Tweet
		Group 1
1	WEB	@tkasputis Thanks for "the follow"! You can also find us on the web http://t.co/5wr10vE3 and Facebook http://t.co/9yvujCkJ
2	KNOWLEDGE SHARING	What is knowledge? Science, hard data? Or knowledge held by fishermen?" - does the answer to this shape how we collect information? #CFP
3	INTERNATIONAL DAY	Going global: International perspectives on #RRI #Bulgaria #RRI_practice meeting https://t.co/E9o1lBYp9r
4	REGISTRATION	@ISPRA_Press Help us spread the word about the #GAP2 Intl Symposium! Registration now open! Link here: http://t.co/Oa7jEzouY6.
5	FINAL CONFERENCE	#RRI #SDGs #climatechange See talk by Barron Joseph Orr at the @RRITools Final Conference https://t.co/wbNGzfw3VQ https://t.co/trXMtihzZv
		Group 2
6	CLIMATE CHANGE	Now: Our Common Future under Climate Change Paris 2015 #CFCC15 #climate conference in preparation of #COP21 Videos: https://t.co/A4FYx05PMS
7	ENVIRONMENTAL JUSTICE	@seharyeli you're follower 700 at EJOLT. Can you tell us which #environmental #justice struggle you're familiar with? Others: let us know!
8	ACTION PLAN	@uduakarchibong1 University of Chemistry and tech Prague team sharing their action plan @genovatecafe @GenovateUnina https://t.co/n5U0SM3vQ2
		Group 3
9	NEWS ROUND	@BeyondAid @BHRRC bad news for Ecuador AND environmental justice. Maybe they make a better chance in Latin-American courts?
10	TOP STORIES	Should #science #journalists read the #papers on which their stories are based? http://t.co/KW0bbZ2p
		Group 4
11	LECTURE; WATCH #NOBELLAUREATE	He'll give another #LindauLecture at #LiNoEcon. Watch #Nobel Laureate P.A. Diamond's lecture on #unemployment: https://t.co/wmqpqVv0He
12	TALK BY PROF	Involving Industry & markets" Prof Martina Schraudner, @TUBerlin_PR/ @fraunhoferfokus talk at #gendersummit http://t.co/KHXTH2a #science
13	VIDEO	Spotlight on a project at #EUCYS 2010... Check this video out—EUCYS_2010_NORWAY.mov http://t.co/jCvcTMq via @youtube
		Group 5
14	WATER MANAGEMENT	During a workshop in Tunis, 31 participants discussed how water management options could be implemented in an... https://t.co/hVeZW3h9Pi
15	FISHING INDUSTRY; SUSTAINABLE FISHERIES	If you're interested in #fish #fishing#fisheries management, #collaborations between science &fishers or #livelihoods- follow #FDI2014
16	FISHERS AND SCIENTISTS	@Welsh_Fishermen -working with scientists & gov to ensure the long-term sustainability of their fisheries (via FishNews) http://t.co/RCXd0KmSew
		Group 6
17	BLOG POST	You can now read all of the blog posts from the Italian-Dutch #GAP2exchange in one place. Check it out: http://t.co/0KPBfEffkE @ISPRA_Press
18	REPORT PUBLISHED	The Royal Society report published on 21 June 2012 the report "#Science as an #open enterprise" http://t.co/ENdUaHfd http://t.co/17XKpxy2
19	OPEN ACCESS	Have you visited ROARMAP yet? THE international registry with over 600 open access mandates and policies! http://t.co/zPu9rIAXLe
20	FOSTEROPEN SCIENCE; OPENSCIENCE	Blogpost by @ivnieuwe on the #fosteropenscience workshop organised by VLIR in Brussels http://t.co/IxPRCDgcuY #opendata #openscience
21	AVAILABLE; WEBSITE	Register as a user at the #Scientix website and meet more than 6200 other #STEMteachers online! Sign up here - . . . https://t.co/Rsmd3ZDKYN
22	NEWSLETTER	The new issue of the Ark of Inquiry Newsletter is out now. Download and share via the following link: https://t.co/z1sOBwWH7r
		Group 7
23	RRI TOOLKIT	New in the #RRI Toolkit What is science's crisis really about?—article by @AndreaSaltelli & @SFuntowicz . . . https://t.co/xob2rfG7oh
24	STEM EVENTS	Have a look at this #ScientixEvent for #STEMDiscoveryWeek! Discover more events or submit your STEM event here: https://t.co/hyeNfFYYs0

Table 6. *Cont.*

No	Name	Example Tweet
25	AWARD! DEADLINE	#Teachers! Last chance to register for @DesignSquad! Deadline to apply is tomorrow! Find more info here > https://t.co/wY1dWzbXpB
26	MEDIA	Understanding the very idea of ethics in sci research is a matter of social responsibility &media can & should play a role in this #sciencemedia
27	GENDER EQUALITY	Initiatives to promote gender equality in STEM @uduakarchibong1 https://t.co/XvdGQmLAUR
28	CONTESTANT	#EUCYS flashback: #Swiss contestant Fabian Gafner, 2009 1st-prize winner, on his project @universciencetv – http://t.co/KMTrSrTl
29	STEM TEACHERS	#STEMAhead is a new competition for #STEM teachers! Go #Back2School this autumn and you may win a prize! More here: https://t.co/55ySS4fh3P
30	SOCIETY RELATED ISSUES; TIME TO APPLY	Did you apply for our #SummerSchool on #science in #society related issues in #pandemics? There's still time to do it http://t.co/3nez6Gn9Hr
31	DISCUSSION	Join GenPORT e-Discussion: Incorporating #Gender in Climate Action #H2020 @UNFCCC @COP21en https://t.co/0Abn0Yv02w https://t.co/ZL2KkjnU6W
32	PUBLIC ENGAGEMENT	Leo Hennen: "Radical shift -From enlightening and educating the public to bring them into the system" #rri #engage2020
33	RESPONSIBLE INNOVATION	Find out what Responsible Research and Innovation is! https://t.co/47LuMXpvO5 #ValentinaAmorese @RRITools #RRI
34	CHILDREN UNIVERSITY	Workshop for organizers of Children's Universities at the University of Magdeburg/Germany. Rector Strackeljan... http://t.co/1w4sc05AZA
35	CAREER RESEARCHERS	New Resource on #GenPORT: #Career Trajectories of Male and Female Career Development #Award Recipients #gender https://t.co/2BTyGlnXfj
36	WEBINAR	Join the #webinar on Global Ocean Science Education on 19 December - register here: https://t.co/KnrA8R2Piq #OceanLiteracy @emseassociation
37	EVENT IN BRUSSELS	Win a trip to Brussels by taking part in our #AllSTEM competition with your #STEM event or video! Participate now ! https://t.co/Fn1kWH4hYh
38	SPACE; COMPETITION	#space_awe announced the competition to celebrate and acknowledge space science teaching! Follow instructions here: https://t.co/A4BZRvoH9I
39	PLANS; ETHICS	#Ethics has the main role in the spread of #epidemics. But few EU #flu #pandemic plans care https://t.co/VZ3ECqigZB
40	SCIENCE	First International perspective by Zhao Yandog of the Chinese Academy of Science and Technology for Development. #rriperspectives

3.4. Impact of Projects on Twitter

The impact of projects on Twitter is presented based on the statistics of tweets and retweets, retweets of tweets, retweets of retweets, followers and following Twitter accounts, as well as the Spearman's correlation analysis of tweet impact indicators.

Table 7 presents the Twitter statistics for Science in Society FP7 projects during the total project time. As shown in Table 7, during the total project time, 55 Twitter accounts belonging to the Science in Society FP7 projects generated 64,973 tweets, out of which 16,373 were retweeted. The owners of the observed Twitter accounts overall had 43,487 followers. At the same time, they followed 30,563 other Twitter accounts. There were a total of 35,571 retweets of tweets during the total project time, and there were 859,593 retweets of retweets during the same time.

Table 7. Twitter statistics for Science in Society FP7 projects during the total project time.

	N	Minimum	Maximum	Mean	Standard Deviation	Total
Tweets	55	6	16,341	1181.33	2575.93	64,973
Retweets	54	0	2418	303.20	474.22	16,373
Followers	55	8	9290	790.67	1657.88	43,487
Following	55	0	7268	555.69	1054.41	30,563
Retweets of tweets	55	0	8933	646.75	1410.16	35,571
Retweets of retweets	55	0	292,392	15,628.96	48,984.71	859,593

The Twitter statistics for Science in Society FP7 projects monthly are presented in Table 8. Across all Twitter accounts belonging to the Science in Society FP7 projects an average of 49.54 tweets were generated per month. At the same time, the number of retweets was 10.48 on average per month. Concerning the followers, Science in Society FP7 projects had an average of 74.45 followers monthly, while they followed an average of 29.96 other Twitter accounts. On average, monthly, there were 19.89 retweets of the analyzed tweets. Moreover, there was an average of 905.02 retweets of retweets per month.

The highest and lowest values of tweets and retweets per month are presented in Table 9. As shown, the highest number of tweets per month is 1361.75, while the lowest is only 0.69. Concerning retweets, the highest number of retweets per month is 158.17, while the lowest is 0.

Table 8. Twitter statistics for Science in Society FP7 projects per month.

	N	Minimum	Maximum	Mean	Standard Deviation
Tweets/month	55	0.11	1362	49.54	184.59
Retweets/month	54	0	158	10.48	23.48
Followers/month	55	0.15	493	28.37	74.45
Following/month	55	0	186	16.40	29.96
Retweets of tweets/month	55	0	229	19.89	42.99
Retweets of retweets/month	55	0	24,366	905.02	3949.03

Table 9. Highest and lowest values of tweets and retweets per month.

Extreme Values	Rank	Tweets/Month	Retweets/Month
Highest	1	1361.75	158.17
	2	215.21	67.17
	3	179.89	39.46
	4	90.1	25.8
	5	80.58	22.92
Lowest	1	0.13	0
	2	0.31	0
	3	0.58	0
	4	0.67	0
	5	0.69	0

Table 10 presents the project and tweet statistics concerning the topics extracted in the earlier analysis of topic mining. Overall, the highest number of Science in Society FP7 projects (52) tweeted about the topic Available; Website containing the keywords "available", "website", "online" and "programme". The second-highest number of projects (49) tweeted about the topics of Science, Event in Brussels and Final Conference. However, out of the 40 extracted topics, the lowest number of Science in Society FP7 projects (22) tweeted about the Environmental Justice topic. The highest number of tweets was obtained within the topic of Science (2229 tweets), whereas the lowest was obtained within the Action Plan topic (236 tweets). Concerning retweets, the highest number of retweets was achieved under the topics of RRI Toolkit and STEM Events (3535 retweets), whereas the lowest number of retweets among the observed topics was noted in the case of the Water Management topic with only 29 retweets. The highest average of followers per project was present in the Climate Change topic (2011.30), whereas the lowest average of 829.7 followers was noted in the case of the Available; Website topic. The average number of retweets was the highest in the case of the Space; Competition topic with an average of 4.99 retweets, whereas it was the lowest in the case of the Water Management topic with an average of 0.07 retweets.

Table 11 presents the tweets with the largest number of retweets, showing the goals of the presented tweets, as well as the tweet statistics and the acronym of the Science in Society FP7 project which was the author of the presented tweet. The author of the tweet with the highest number of retweets (83) is the SCIENTIX 2 project, which originated from Belgium.

Table 10. Project and tweet statistics per topic.

No	Name	Keywords	Number of Tweets with At Least One Word	Number of Retweets	Number of Projects	Average Number of Followers per Project	Average Numbet of Retweets
1	CLIMATE CHANGE	CLIMATE; CHANGE	390	524	31	2011.30	1.34
2	WEB	WEB; FACEBOOK; FOLLOW; THANKS	1007	386	47	901.6	0.38
3	TOP STORIES	TOP; DAILY; STORIES	458	330	32	1227.50	0.72
4	RRI TOOLKIT	RRI; TOOLKIT; RRITOOLS	1239	3535	31	1034.70	2.85
5	LECTURE; WATCH #NOBELLAUREATE	LECTURE; NOBELLAUREATE; WATCH; NOBEL	613	889	34	1136.20	1.45
6	STEM EVENTS	EVENTS; DISCOVER; STEM; EVENT	977	3535	46	920.3	3.62
7	ENVIRONMENTAL JUSTICE	JUSTICE; ENVIRONMENTAL	255	677	22	1577.50	2.65
8	AWARD! DEADLINE	DEADLINE; AWARD; PRACTICE; EDITION; APPLY	530	1161	41	1010.90	2.19
9	FISHING INDUSTRY; SUSTAINABLE FISHERIES	FISHING; FISHERIES; FISH; SUSTAINABLE; INDUSTRY	1124	1361	36	1104.30	1.21
10	MEDIA	MEDIA; SCIENCEMEDIA; SOCIAL	645	445	38	1051.70	0.69
11	GENDER EQUALITY	GENDER; EQUALITY	1334	2227	25	1096.50	1.67
12	CONTESTANT	COUNTRY; PRIZE; CONTESTANT	306	470	29	1235.90	1.54
13	BLOG POST	BLOG; POST; READ; EXCHANGE	1036	1979	44	962.6	1.91
14	OPENA CCESS	OPEN ACCESS; POLICIES; ACCESS	1029	2380	36	1107.50	2.31
15	FINAL CONFERENCE	CONFERENCE; FINAL	1047	1493	49	877.2	1.43
16	NEWS	NEWS; ROUND; STORIES	586	952	40	1027.40	1.62
17	STEM TEACHERS	TEACHERS; SCHOOL; STUDENTS; STEM	764	3362	38	1026.40	4.40
18	WATER MANAGEMENT	MANAGEMENT; WATER	406	29	29	1295.20	0.07
19	SOCIETY RELATED ISSUES; TIME TO APPLY	ISSUES; SOCIETY; APPLY; TIME	768	1242	43	975.8	1.62
20	VIDEO	VIDEO; YOUTUBE	453	769	41	992.4	1.70
21	DISCUSSION	DISCUSSION; PANEL; JOIN	670	1651	42	996.4	2.46
22	PUBLIC ENGAGEMENT	ENGAGEMENT; PUBLIC; ENGAGE	528	805	42	994.6	1.52
23	FOSTEROPENSCIENCE; OPENSCIENCE	FOSTER OPEN SCIENCE; OPEN SCIENCE; OPEN DATA; TRAINING;	1092	820	39	1044.1	0.75
24	AVAILABLE; WEBSITE	AVAILABLE; WEBSITE; ONLINE; PROGRAMME	797	1477	52	829.7	1.85
25	RESPONSIBLE INNOVATION	INNOVATION; RESPONSIBLE	751	1355	41	876.3	1.80
26	CHILDREN UNIVERSITY	CHILDREN; UNIVERSITIES; UNIVERSITY	528	480	39	1051.8	0.91
27	TALK BY PROF	TALK; PROF	386	548	36	1125.1	1.42
28	ACTION PLAN	ACTION; PLAN	236	356	36	1123.1	1.51
30	CAREER RESEARCHERS	CAREER; RESEARCHERS; FEMALE	467	885	36	1126.7	1.90
31	NEWSLETTER	NEWSLETTER; ISSUE; POLICY	950	1677	48	890.1	1.77
32	WEBINAR	WEBINAR; REGISTER; MISS	418	1434	41	1017.1	3.43
33	EVENT IN BRUSSELS	BRUSSELS; TAKING; COMPETITION; EVENT	449	2025	49	869.2	4.51

Table 10. *Cont.*

No	Name	Keywords	Number of Tweets with At Least One Word	Number of Retweets	Number of Projects	Average Number of Followers per Project	Average Numbet of Retweets
34	SPACE; COMPETITION	SPACE; COMPETITION; RESOURCES; TEACHING	459	2290	41	997.9	4.99
35	KNOWLEDGE SHARING	SHARING; KNOWLEDGE; INFORMATION	507	569	41	1011.1	1.12
36	FISHERS AND SCIENTISTS	SCIENTISTS; FISHERS; FISHERMEN	693	1001	30	1271.1	1.44
37	PLANS; ETHICS	PLANS; ETHICS; ROLE	427	777	38	1072.8	1.82
38	REPORT PUBLISHED	REPORT; PUBLISHED	490	880	40	1028.3	1.80
39	SCIENCE	SCIENCE; TECHNOLOGY	2229	3366	49	877.8	1.51
40	INTERNATIONAL DAY	DAY; INTERNATIONAL; MEETING	882	1328	48	889.5	1.51
41	REGISTRATION	REGISTRATION; HELP; LINK	443	770	40	1030.8	1.74

Table 11. Tweets with the largest number of retweets.

Tweet	The Goal of the Tweet	Acronym	Number of Retweets	Number of Tweets	Number of Followers	Number Following
We are proud to announce that #Scientix is selected for the top 100 global innovations in education at #BETT2017! https://t.co/yWNlO76wvZ	Project achievement	SCIENTIX 2	83	8393	9290	7268
Canadian lawyers side with Ecuadorian villagers in attempts to enforce a judgement on Chevron http://t.co/W6XeJPPEME http://t.co/7XWIgmXAsa	Environmental justice	EJOLT	70	2013	6015	1657
From Jan 2017, research data is open by default, with possibilities to opt out https://t.co/upxVBWsfd1 https://t.co/RY8RVqRzAO	Interesting possibility	FOSTER	62	1713	2603	2231
No more #mountaintopremoval coal mining in Laciana (Spain) http://t.co/hyiunRIglx @MiningWatch @mining @londonmining http://t.co/gKH51n91GS	Environmental justice	EJOLT	52	2013	6015	1657
BREAKING: Legal case against CEO of #Chevron submitted to #ICC for crimes against humanity http://t.co/fHO9PXaGyC http://t.co/ScOCJFEEPO	Environmental justice	EJOLT	49	2013	6015	1657

Table 11. *Cont.*

Tweet	The Goal of the Tweet	Acronym	Number of Retweets	Number of Tweets	Number of Followers	Number Following
Big themes of the #greenlight4oa conference so far as captured by @Denkschets https://t.co/PcFu6HsAuG	Event	PASTEUR4OA	49	1092	1140	826
'Told you'! The cartoon on #openaccess just shown by @bernardrentier is made by @hochstenbach https://t.co/7jITZ6cvr9	Information	PASTEUR4OA	49	1092	1140	826
#Teachers! Join this #STEM competition and you might win a trip to #Brussels! Please RT! More info here: https://t.co/KqzwOv5Cmx	Interesting possibility	SCIENTIX 2	48	8393	9290	7268
We are looking for teachers to join our 3rd #Scientix Ambassadors Training Course! Want to become our Ambassador? https://t.co/xvbwhAn2vo	Interesting possibility	SCIENTIX 2	44	8393	9290	7268
NEW: The Global Atlas of Environmental Conflicts http://t.co/q3XmkFDw1H #environmentaljustice Find, click... action! http://t.co/J819UV7cXg	Environmental issue	EJOLT	42	2013	6015	1657
Is #OpenScience an essential rsrch skill Grad Schools should train in prep for #REF2020 ? #OpenSci4Doc @HEIRRI_	Information	FOSTER	41	1713	2603	2231
We have published the 8 science books for our #STEMDiscoveryWeek competition! Start reading now #WorldBookDay … https://t.co/Ve8OtQONEX	Project achievement	SCIENTIX 2	41	8393	9290	7268
,Celebrating #WomenInScience on #InternationalWomensDay https://t.co/XCnQICZQkF	Information	LIN10	40	16,341	5913	1209
New in the #RRI Toolkit Providing researchers with skills & competencies to practise #openscience by … https://t.co/XPAy7cewMG	Interesting possibility	RRI TOOLS	40	6476	2935	1994
This article shows how important it is to increase students' self-confidence and motivation in #STEM subjects https://t.co/PwuiXzi0Eg	Information	SCIENTIX 2	40	8393	9290	7268

The results of the Spearman's correlation analysis of tweet impact indicators are presented in Table 12. All the presented correlations are significant at the 1% level, and all of them are positive. A very strong positive correlation (0.922) among the observed tweet impact indicators is visible between monthly tweets and monthly retweets. A strong positive correlation (0.822) is also present between monthly tweets and the number of following Twitter accounts every month.

Table 12. Spearman's correlation analysis of tweet impact indicators.

	Tweet_Month	RTweet_Month	Followers_Month	Following_Month
Tweet_Month	1	0.922 **	0.792 **	0.822 **
RTweet_Month		1	0.765 **	0.795 **
Followers_Month			1	0.739 **
Following_Month				1

** Correlation is significant at the 0.01 level (2-tailed).

4. Discussion

As mentioned in the literature review, the impact evaluation of science should include other information sources in addition to academic citations [5]. This research focuses on the analysis of the impact evaluation of science on Twitter. Although the results revealed that a moderate percentage of the observed projects use social networks, there is still room for improvement. For instance, Table 2 reveals that only 30% of the observed projects use Twitter, which is lower than a third of the total number of projects included in the Science for Society programme. Following recommendations of the European Union regarding the maximization of the impact of science, and bearing in mind that social networks are a great means of reaching a wide audience, the number of projects using Twitter (or other social networks) should be greater.

Besides, when performing exploratory data analysis, the results presented in Table 4 revealed that among 50 of the most frequently used words in tweets published from the Science in Society FP7 projects' Twitter accounts, the most-used word is "science". Other words in the top five are "gender", "RRI", "conference" and "project". Considering that the sample in this research is composed of European research projects focused on science in society, it makes sense that the most-used word is "science". Nevertheless, the word "society" has a low frequency in the context of the results since it is situated below the middle line of the top 50 words and can be found in the 28th place. Furthermore, if the goal of using Twitter for spreading impact is to be more connected to the public, researchers should also use other keywords such as the words that people use in their daily life on Twitter. Words such as "science", "RRI", "conference" and "project" are, in fact, specific concepts from academia and could limit the scope. However, the keyword "gender" is a concept with a high frequency (being in the second place of the top 50 most-used words) and indicates the relevance of this topic for all projects. At the same time, this concept has a wider audience than the others and could easily connect with a more diverse range of people and citizens than the others.

Furthermore, the exploratory analysis presented in Figure 2 and the proximity plot also revealed that the most frequently used words in addition to the word "science" are "gender", "women", "society", "innovation" and "education". This finding means that all of the listed words are topics to which the projects paid attention. The concern about women in science or the gender dimension of science is also present in this sample. However, other noted words such as "society", "innovation" and "education" indicate that science also aims to be more related to society. Besides, innovation and education play a crucial role in this aim.

Some of the topics highlighted in Figure 2 and in Table 5, which present topic mapping and tweet mining, reveal some crucial ideas for advancing in the improvement of the use of Twitter. First, the phrase "final conference" has a high number of cases (1047 hits), which makes sense because most researchers mainly use Twitter for final conferences. However, that can also be a limitation. Researchers should use Twitter during the whole lifetime of a project. Nevertheless, in this research,

although there were some projects in which the researchers used Twitter during the entire lifetime of the observed project, a great number of projects did not. If the aim is to engage citizens in the research and increase their interest, using Twitter and sharing project-related tweets should be done from the beginning of a project. One of the challenges to keep in mind is the question of how the use of Twitter could be improved to drive the impact of science from the beginning of a project. For instance, involving a greater number of citizens in research could be done using appropriate keywords and explaining the different steps of the project. Moreover, sharing the initial findings of the studies under the projects, and not only the final results, as well as sharing how the project results could improve the living conditions or societal challenges could be useful in increasing citizens' engagement.

Other examples of topics that captured attention in this research are climate change and sustainable fisheries. These two examples indicate the relevance of the mentioned topics. Since the phrase "climate change" is a keyword with a high-frequency Twitter hashtag in general, projects that use this keyword have greater chances of disseminating the obtained results in global conversations. However, the phrase "sustainable fisheries" is an example of a specific word combination that catches the attention of those citizens who are concerned about improving the sustainability of fisheries and those who work in this sector. This finding could also be useful for developing an impact strategy. Researchers who are working in a specific sector or area could pay attention to the hashtags that are most used by the people who are working in a specific area or are interested in it. In that case, the impact strategy should include publishing tweets under those identified hashtags and others that are relevant to the project.

When discussing the impact of projects on Twitter, Table 7, which presents Twitter statistics for Science in Society FP7 projects during the total project time, also reveals some interesting findings. It can be noted that there is a huge difference between projects that use Twitter with a high frequency and those that use Twitter only occasionally. Bearing in mind that the use of Twitter is one of the ways to engage citizens in the results obtained under a project, researchers should recognize the importance of maintaining the activity of a project Twitter account. However, as stated above, the content that is published is also crucial in this regard.

5. Conclusions

The research presented in this paper includes the identification of social network accounts belonging to the observed projects and the extraction and analysis of the related data. First, the analysis of the social media usage for the Science in Society FP7 projects was conducted. Next, an exploratory data analysis of the tweets published by the observed projects' Twitter accounts was conducted. Besides, topic mining analysis and analysis of the impact of projects on Twitter were carried out.

The results reveal moderate usage of Twitter among the projects under the Science in Society FP7 programme, as well as high and moderate positive correlations with owning different social network accounts. Based on the topic mining analysis, identification of topics in tweets was performed, and a topic map of the tweets was created, revealing seven groups of topics with regards to the cluster analysis of the topics used in the tweets published by the observed projects. The analysis of the impact of the projects on Twitter resulted in the identification of large differences among the projects that actively use Twitter and those that use it occasionally. Additionally, strong positive correlations were noted between the number of monthly tweets and monthly followers.

5.1. Practical Implications

This study provides some interesting findings that could serve as a basis for practical implications. Bearing in mind that the European Framework Program Horizon 2020 states impact as one of the key items in research calls evaluation, and the Framework Program Horizon Europe aims at maximizing impact, this research sheds light on the topic of evaluating and achieving science impact through social media usage, namely, through Twitter. Following the above-stated trends indicated by eMarketer (n.d.) regarding the tendency to reach 3.02 billion social networks users by 2021, as well as the findings provided by Eurostat (n.d.) indicating that 54% of the EU population uses social networks,

it is clear that the end-users play a pivotal role in achieving science impact. However, as mentioned above, the results of the research revealed moderate usage of social networks, including among others, Twitter. Moreover, it was revealed that the use of hashtags is not always in line with reaching a broad audience and that the frequency and continuity of Twitter use are not high and are mostly related to the final phases of a project. In that sense, it is highly significant for those in the research practice to understand the importance of using Twitter (and other social networks) continuously and frequently from the very beginning of a project, as well as to pay attention to content and hashtags. Based on the results, an important recommendation is to deliver SEO training to research teams to improve visibility, dissemination and impact, considering that the use of social media accounts plays a crucial role in expanding the impact of science.

5.2. Theoretical Implications for Further Research

Following the work presented by de Jong et al. [7], recommendations for further research include the employment of a case study methodology for investigating the impact evaluation of science on social networks. The research presented in this paper revealed the impact of projects on Twitter based on tweets and retweets statistics in total. For further research, it would be interesting to identify projects that had the greatest impact and those that had the lowest impact among projects using Twitter. In that way, a multiple case study methodology could be employed aiming to shed some light on the ways that the identified project has been using the social network, namely, Twitter. Moreover, a case study methodology could provide deeper insight into the reasons behind achieving a greater impact than other projects, which could lead to the identification of guidelines for project managers in using social networks in the future.

5.3. Practical Recommendations for Project Managers

The findings of the presented study suggest several courses of action for practice. The first recommendation for project managers is to create a project Twitter account at the very beginning of a project and to then maintain activity through the whole lifecycle of the project. It is highly important to achieve continuous publishing of tweets to engage a larger number of citizens, which leads to a greater science impact in general. Moreover, based on the topic mining analysis presented in this research, the recommendation for project managers also includes the early identification of relevant hashtags, which can then be used in tweets during the whole lifetime of the project. For example, the relevant hashtags should include those closely related to the topic, while using keywords that are more commonly used in daily Twitter activities and are, therefore, closer to the wider public. Additionally, relevant hashtags should include keywords that are close to the target groups (e.g., people employed or interested in the project research area). It is important to bear in mind that hashtags should not be limited only to academic words because, if that is the case, the project results do not reach a broad audience.

To summarize, there are four key practical recommendations for project managers:

- to maintain an active Twitter account during the whole project lifetime;
- to publish tweets frequently and continuously;
- to choose hashtags related to the project results that are most useful for citizens;
- to pay attention to the tweet content in terms of publishing project results, which could be useful for improving living conditions.

5.4. Paper Limitations and Further Implications

Although this research extends the body of knowledge, some limitations should be recognized. One of the limitations of this study is the fact that the sample is limited to the projects' Twitter accounts, and the collected data refer only to the data published by the projects' Twitter accounts. Therefore, in future research, other data could be integrated into the study. For example, tweets published by

other Twitter accounts that refer directly to the results of the research of a certain project could be extracted and included in analysis. Furthermore, other possibilities could be integrated into future research. One such possibility would be to include other social networks into the analysis such as Facebook and LinkedIn. Moreover, it would be interesting, relevant and useful to compare through a correlation analysis the academic citations of published work by the 55 projects with the number of tweets, in order to potentially explore the similarities and divergences between impacts. Finally, it is important to mention that the analysis has a limitation with regards to the countries where the projects have been developed. Twitter had a different degree of influence and presence depending on the country and when this social network gained and increased popularity in disseminating data using social media [48,49]. In this respect, in future developments it will be interesting and relevant to explore where the projects were based.

The previous studies in the field deepened our understanding of the use of social media by users and reflected the arguments for using Twitter by scientists because of the impact in general. As mentioned, Parra-López et al. [22] reveal the benefits of using social networks in terms of the usage of information derived from social media, as well as higher user motivation to use social media in the decision-making process. Additionally, the benefits of social network usage are also reflected in faster knowledge transfer, as argued in the work of Grande et al. [15]. There are also studies presented that are based on a specific area, such as healthcare [29,30]. However, none of the previous studies investigated the use of Twitter performed by EU research projects' Twitter accounts. In that sense, the research produced in this paper presents novel findings and provides a scientific contribution to this specific area of knowledge. The results obtained in this research could be useful in rethinking the strategy of Twitter use for researchers and project advisors in terms of improving it.

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