Toxicology in Vitro 59 (2019) 51–54

Contents lists available at ScienceDirect

Toxicology in Vitro

journal homepage: www.elsevier.com/locate/toxinvit

The use of social media in scientific research and creative thinking

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ABSTRACT

Young researchers dedicate rightfully most of their time to core knowledge production via laboratory experiments, reading peer-review literature, publishing own results, attending conferences whenever possible as well as undertaking trainings on writing grants, papers among many other activities However, the authors argue here that restricting them to this unique set of activities is jeopardizing creativity and reducing awareness of a more complex picture in science. Other fields linked with social sciences, including scientometrics and epistemological areas covered during conferences and continuous education, may contribute to a more productive working environment for young researchers. To illustrate this, a smart use of social media is described as well as an example of a session. Furthermore, some general suggestions for implementing these activities and opening silos are discussed to increase creative thinking and to make *in fine* better science.

1. Introduction

Once or twice per year, young researchers are exposed to core knowledge of their specific field during scientific national or international conferences, symposia or any other scientific events. At that occasion, they have the opportunity to meet their peers and face the challenges of oral presentation and posters. Nevertheless, secondary but critical aspects seem to lack during these meetings. Indeed, probity, fraud, revolving doors, science communication, knowledge about authorship, reproducibility of results, smart use of social media, understanding scientific journals business models, identifying predatory journals, critical thinking in scientometrics, acknowledgement about the code of misconducts or gender inequality are rarely the focus of an entire session and are at best addressed at the edge. Moreover, lab productivity on the bench is a key component of robust and reproducible results but is devoid of exposure or is limited to congress booth. For example, the "Internet of things" is entering in the lab and e-productivity should be considered by doctoral students and post-doctoral researchers if not already done (e.g. Bluetooth pipettes connected with e-lab books.).

Such topics that do not emerge during conventional scientific congresses should be more heavily disseminated within a congress or during training to empower young researchers. Some initiatives have been heralded already (Bosch, 2018) or are in motion ("COST Academy, 2019"; "Elsevier Researcher Academy, 2016"). These assets as well as science advocacy (March for Science, 2019.; Sense about Science – Because Evidence Matters, 2019)or scientific advice to policy makers (i.e. presenting facts and values European Researchers' Night | Marie Skłodowska-Curie Actions (2018); Pielke Jr, 2007) can be of great importance along the core knowledge within post-truth era. This concise featured article is an attempt to highlight some of the benefits through smart use of social media as well as to provide food for thoughts for the life science community.

2. Smart use of social media

Scientists are regularly asked to communicate about their work to a lay audience and get out of their "ivory tower". Multiple face-to-face formats exist such as open days in laboratories, education in classrooms, or even meetings in the pub (*Pint of Science | Pint of Science*, 2019.; Science in the Pub Adelaide, 2019; "*SoapboxScienceSoapboxScience | Bringing Science to the People*, 2018) to connect with the broader public. However, when it comes to e-communication, social media and open source platform are the most efficient way to spread the news and connect:

- For example, Wikipedia covers all the topics with multiple levels of complexities and appears in all the top 5 first results when a Google search is performed. Keeping in mind that Internet users never look beyond the first 10 results and rarely go to the second page, Wikipedia should not be neglected.
- As regards Twitter, approximately 500 million tweets are tweeted each day. Tweets are tweeted each day by both scientists and non-academics.

Nevertheless, when colleagues and peers hear about creating a Wikipedia page or a Twitter account to "engage" with the e-community, it is at best considered as a hobby of no scientific value whatsoever or

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https://doi.org/10.1016/j.tiv.2019.04.006
Received 28 January 2019; Received in revised form 2 April 2019; Accepted 3 April 2019
Available online 05 April 2019

even a waste of time. However, Dr. Jess Wade, gained attention recently for her ambition in writing one Wikipedia page per day to increase the number of underrepresented scientists and engineers on Wikipedia (Academic Writes 270 Wikipedia Pages in a Year to Get Female Scientists Noticed | Education | the Guardian, 2019. This prejudice is true not only for Twitter and Wikipedia but also for Facebook (Van Noorden, 2014). This is quite unfortunate since Twitter accounts for 326 million persons (Statista, 2018), Facebook has two billion active users ("Statista" b) and 5–8 million Wikipedia pages ("Wikipedia statistics (English), 2018") are currently published.

Taking into consideration these numbers, the authors wanted to investigate the role of social media, in particular Twitter, on dissemination regarding the 3Rs concept. First introduced in 1959, the 3Rs principle calls for Replacement, Reduction and Refinement of animal experimentation, especially in life sciences research and regulatory toxicity testing. Twitter allows data mining and encourages to develop Application Programming Interfaces (API). The next step was to program a dedicated API, which has extracted more than 430,000 tweets from October 2014 to June 2017 based on a specific set of hashtags: #animaltesting OR #animalfreetesting OR #animalfreetests OR #animalexperiments OR #3Rs OR #3R OR #BeCrueltyFree OR #endanimaltesting OR #stopanimaltesting OR #stopvivisection.

2.1. Limitation and bias

- This analysis was highly dependent on the extracted hashtags.
- Users may not use hashtags "#" and would not be included in the data base analysis. Therefore, the total amount of tweets considered here could be significantly lower than the actual number of tweets on the above-mentioned topics.
- Twitter per se does not require accurate user information (e.g. location, user name, age, gender). Therefore, authors' analysis and recommendation may be more approximate than for other social media.
- #3R has multiple meanings and is not limited to "replace, reduce and refine" when it comes to alternatives to animal testing but can also be referred among others to "replace, recycle, reuse". However, this did not significantly increase the total amount of tweets.

2.2. Community analysis

2.2.1. General description

The number of tweets collected over this period was about 430,000 tweets over 33 months compared to 500 million tweets posted every day (Twitter Usage Statistics - Internet Live Stats, 2018). Besides the number of tweets, the number of users is approximately 200,000 people (see Fig. 1A) which makes 0.06% of the whole Twitter community. This increased steadily since 2014 based on the hashtags extracted. However, a plateau was reached. Three possibilities can explain this plateau: 1) the hashtags used were not trendy anymore 2) the topic was of no interest for the micro-blogging community or 3) the "news" was decreasing.

2.2.2. Sentiment analysis

Sentiment analysis (Yelena, 2009) in R-language was developed to categorise wording content of the tweet into a specific emotion (Mohammad and Kiritchenko, 2015). The following sentiments were used:

2.3. Surprise, disgust, anticipation, joy, sadness, anger and fear

In absolute total amount (see Fig. 1B), there were rather more negative feelings (sadness, fear, anger, disgust) expressed compared to positive ones (surprise, anticipation, joy). Nevertheless, overtime, the positive sentiment seemed to be predominant, which could indicate improvements for animal welfare in animal experimentation.

2.3.1. Most popular users

A most popular user is defined by the number of his/her tweets with the "#" divided by number of retweets of his/her tweet. From the top 10 popular users (see Fig. 1C), there is Ricky Gervais (@RickGervais) a British actor and stand-up comedian regularly tweeting about animal welfare and publically engaging on that topic. More than 50% were Non-Governmental Organisation (NGOs) such as Humane Society International (@HSIGlobal), Humane Society of the United States (@Humanesociety), Fondation Brigitte Bardot (@FBBporteparole), Souls Without a Voice (@SoulWithoutVoic), the Dodo (@dodo) specialized in beautiful animal pictures, Protect Wildlife (@protectwildlife) and @termiteking Co-president and founder of "mad rabbits". Last, there is one cosmetic company (@LUSHcosmetics) and one make-up artist (@priscillastamos).

2.3.2. Short conclusion

The novelty here is linked principally to the social medium Twitter mining with respect to the 3Rs field. Nevertheless, the authors' intention was to spotlight the use of social media in science. As mentioned above, Twitter does not trigger waves of enthusiasm but rather skepticism among scholars. Nevertheless, ignoring these new platforms lead *in fine* exposing categories of users to bots and trolls proliferating and disseminating fake information (Iyengar and Massey, 2018). Therefore, monitoring Twitter can be a powerful tool to map user's profiles, concerns and questions over a certain topic. In the context of strict communication, Twitter can be used in quite innovative ways (Lee, 2019). In fact, some unique Twitter accounts can be shared by i) a community (@labioaulabo), ii) a country (Sweden ("Curators of Sweden, 2019")) or iii) even lead to new conference venues (@biotweeps (Caravaggi and James, 2017)). In brief, Twitter's influence is 1) redefining how researchers may communicate their results and passion for science to peers and lay audience 2) allowing to map users, facilitate monitoring and debunk myths 3) challenging scholars academy evaluation in China (Cyranoski, 2017) 4) integrating creative new metrics (Altmetrics (Discover the Attention Surrounding your Research – Altmetric, 2016), PlumX (PlumX Metrics, 2019) or k-index (You, 2014)) to measure excellence and productivity 5) and looking for grant opportunities and new collaborators (Côté and Darling, 2018). Taking these all aspects in consideration, Twitter can be an ideal fertile material for inception of new research ideas.

2.4. Way forward

Circling back to the need for further knowledge permeability for creative thinking, the authors would like to list examples of topics to be used by scientists within congresses and/or during the doctoral training curricula such as "Publish or perish in science" with the following learning pedagogical objectives: a) Scientometrics on impact factors, h-index, … b) discuss authorship and authors ranking c) Code of conduct for scientists d) business models of scientific journal and open science e) how to identify predatory journals.

Other activities could cover i) Gender inequality in science (e.g. Lesbian, gay, bisexual, transsexual – L.G.B.T. (Suri, 2015)), ii) Science collaboration (e.g. Nature index, iii) Social media and scientists: it's complicated… iv) Honest broker in science v) Visual and story-telling.

It might be worth to rethink and adapt skill sets required by young scientists to pursue and fulfill a successful academic career in collaboration with representatives' organizations such as Young European Researcher Universities (YERUN), the guide of European research-intensive universities or the European Council of Doctoral Candidates and Junior Researchers.

Moreover, the authors have recurrently noticed in congresses oral presentations that do not belong to that particular session. The authors would ask for a leap of faith here and suggest having whenever possible a "blue-sky" or "think different" session where scientists would stop skewing abstract title or text for the sake of being selected and could

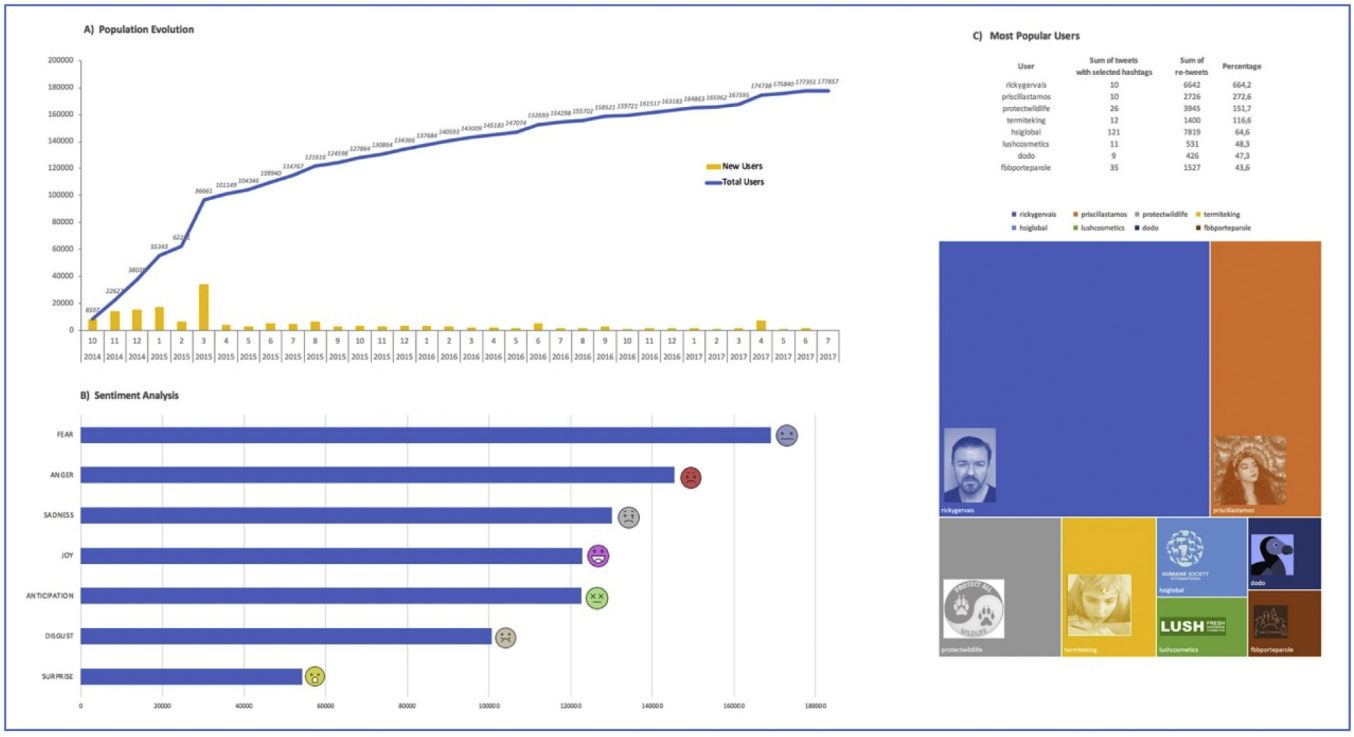

Fig. 1. Analysis of tweets related to 3Rs from October 2014 to June 2017.

present results beyond their field to facilitate cross-fertilizations of ideas.

One could always claim that this problem has been already identified (see Table 1) and that congresses such as European Science Open Forum (ESOF), the American Association for the Advancement of Science (AAAS) or EU funded Marie Skłodowska-Curie Actions provide the right solution. This would be correct. The authors would only argue that such congresses attendance by young researchers is rarely a priority and average success rate for the last four years for the research fellowship program is 15% (*Marie Skłodowska-Curie Actions Statistics Individual Fellowships, 2018*). This leaves still quite a lot of people on the side.

More than anyone else, scientists know the value of curiosity and creativity as drivers for further breakthrough. The same ingredients should be used when it comes to the way we are working among ourselves. Furthermore, there is no particular framework where these suggestions may be implemented. However, "The Logical Thinking Process" (Dettmer, 2007) talks about three different areas of systems:

- **Span of control** includes all those things in a system that we can change on our own.
- **Sphere of influence** includes activities that we can impact to some degree but cannot exercise full control over.
- **Outside environment** includes the elements over which we have no

Table 1
Examples of diverse and varied of soft skills topics currently tackled.

Example of English speaking providers	Examples of soft skills topics	Teaching formats
Association for the Advancement of Science *(AAAS)* European Cooperation in Science and Technology *(COST)* - restricted to beneficiaries	• Science diplomacy • How to engage with policymakers • Using social media to communicate your Action • Storytelling: spotting and writing a good story. Getting people to listen • Shooting and editing a video for your Action • Working with the media – mastering media interviews: Working with the media	Webinars Face-to-face meetings
Elsevier Academy	• Funding • Research data management • Research collaborations • Fundamentals of manuscript preparation • Writing skills • Technical writing skills • Book writing • Fundamentals of publishing • Finding the right journal • Ethics • Open science Publishing in the Chemical Sciences • Fundamentals of peer review • Becoming a peer reviewer • Going through peer review • Social impact • Ensuring visibility	Webinars

influence.

This article represents author's **sphere of influence** and each reader will be in his/her **span of control** to decide whether to discuss, to dismiss or include these suggestions within their own community. This would allow to go beyond "usual suspects" such as grant/paper writing and oral presentation, which are also necessary but taking possibly too much energy. Not all the young researchers would need to master all sets of skills, but at least have the capacity to acknowledge them.

To wrap-up, creative thinking should be about making scientists more open to the global picture. In other words:

1. **Make people better scientists** by learning how to become an "honest broker" in science, reaching out public with social media, lab skills or using visuals for story telling
2. **Make scientists better people** by tackling fraud, probity, conflict of interests, or gender inequality
3. **Make science a better forum** for cross-fertilization of ideas by providing placeholders to nurture creativity and discussion within researchers

Acknowledgements

Francois Busquet wishes to warmly thank Alexandre Angers-Lousteau and Nikolaos Mitrakis for respectively enlightening him with API possibilities and adapting the program on 3Rs.

References

Academic Writes 270 Wikipedia Pages in a Year to Get Female Scientists Noticed | Education | the Guardian. Retrieved March 26, 2019, from. https://www.theguardian.com/education/2018/jul/24/academic-writes-270-wikipedia-pages-year-female-scientists-noticed (n.d.).

Bosch, G., 2018. Train PhD students to be thinkers not just specialists. Nature 554 (7692). https://doi.org/10.1038/d41586-018-01853-1. 277–277.

Caravaggi, A., James, K., 2017. Twittersphere: conferencing in 140 characters. Nature 2017 (549), 7673.

COST Academy, 2019. Retrieved January 14, 2019, from. https://www.cost.eu/academy/ (n.d.).

Côté, I.M., Darling, E.S., 2018. Scientists on Twitter: Preaching to the Choir or Singing From the Rooftops? https://doi.org/10.1139/facets-2018-0002.

Curators of Sweden, 2019. Retrieved January 14, 2019, from. https://curatorsofsweden.com/about/ (n.d.).

Cyranoski, D., 2017. Top Chinese university to consider social-media posts in researcher evaluations. Nature. https://doi.org/10.1038/nature.2017.22822.

Dettmer, H.W., 2007. The Logical Thinking Process: A Systems Approach to Complex Problem Solving. ASQ Quality Press Retrieved from. https://asq.org/quality-press/display-item?item=H1315.

Discover the Attention Surrounding your Research – Altmetric, 2016. Retrieved January 14, 2019, from. https://www.altmetric.com/ (n.d.).

Elsevier Researcher Academy, 2016. Retrieved January 14, 2019, from. https://researcheracademy.elsevier.com/learn (n.d).

European Researchers' Night, 2018. Marie Skłodowska-Curie Actions (n.d.). Retrieved March 26, 2019, from. https://ec.europa.eu/research/mariecurieactions/actions/european-researchers-night_en.

Iyengar, S., Massey, D.S., 2018. Scientific communication in a post-truth society. Proc. Natl. Acad. Sci. U. S. A. https://doi.org/10.1073/pnas.1805868115. 201805868.

Lee, J.-S.M., 2019. How to use twitter to further your research career. Nature 2019.

March for Science, 2019. Retrieved January 14, 2019, from. https://www.marchforscience.com/ (n.d.).

Marie Skłodowska-Curie Actions Statistics Individual Fellowships, 2018. Retrieved from. http://cache.media.education.gouv.fr/file/Actions_Marie_Sklodowska-Curie/37/3/Statistiques_globales_IF30032017_VF_750373.pdf (n.d.).

Mohammad, S.M., Kiritchenko, S., 2015. Emotions evoked by common words and phrases: using mechanical turk to create an emotion lexicon. In: Computational Intelligence. vol. 31. pp. 301–326. https://doi.org/10.1111/coin.12024.

Pielke Jr., R.A., 2007. The Honest Broker. Cambridge University Presshttps://doi.org/10.1017/CBO9780511818110.

Pint of Science | Pint of Science. Retrieved March 26, 2019, from. https://pintofscience.com/ (n.d.).

PlumX Metrics, 2019. Retrieved January 14, 2019, from. https://plumanalytics.com/learn/about-metrics/ (n.d.).

Science in the Pub Adelaide, 2019. Retrieved January 14, 2019, from. https://www.facebook.com/scienceinthepubadelaide/ (n.d.).

Sense about Science – Because Evidence Matters, 2019. Retrieved March 26, 2019, from. https://senseaboutscience.org/ (n.d.).

SoapboxScienceSoapboxScience | Bringing Science to the People. Retrieved March 26, 2019, from. http://soapboxscience.org/Statista (n.d.-a). Retrieved January 14, 2019, from. https://www.statista.com/statistics/282087/number-of-monthly-active-twitter-users/.

Statista, 2018. (n.d.-b). Retrieved January 14, 2019, from. https://www.statista.com/statistics/264810/number-of-monthly-active-facebook-users-worldwide/.

Wikipedia statistics (English). (2018) (n.d.). Stats.Wikimedia.Org. Retrieved from http://stats.wikimedia.org/EN/TablesWikipediaEN.htm

Suri, M., 2015, September 4. Why Is Science So Straight? Retrieved from. https://www.nytimes.com/2015/09/05/opinion/manil-suri-why-is-science-so-straight.html.

Twitter Usage Statistics - Internet Live Stats, 2018. Retrieved January 14, 2019, from. http://www.internetlivestats.com/twitter-statistics/.

Van Noorden, R., 2014. Online collaboration: scientists and the social network. Nature 512 (7513), 126–129. https://doi.org/10.1038/512126a.

Yelena, M., 2009. Sentiment Analysis: An Overview Comprehensive Exam Paper. Computer Science Department, (May).

You, J., 2014. Scientific community. Who are the science stars of twitter? Science (New York, N.Y.) 345 (6203), 1440–1441. https://doi.org/10.1126/science.345.6203.1440.