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Interactive articles: a case study in the *Ciência Hoje* magazine

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Abstract

This paper analyzes a new initiative in Brazil's *Ciência Hoje* magazine, called 'Interactive Articles', aimed at understanding how stakeholders relate to interactivity when writing a science communication article. We investigated participation in two platforms (magazine website and Facebook page) and interviewed the authors concerning the tool's impact on their articles. Comments were examined using intensity analysis and content analysis, while interviews were analyzed with the collective subject discourse method. The study concluded that the novel initiative presented positive results in terms of interactivity and was regarded as public engagement and contextual model of science communication from the interviewed authors.

Keywords

Science and media; Science communication in the developing world; Science writing

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Introduction

Science communication in traditional media has changed dramatically with the advent of new technologies in the field. Such changes include possibilities to direct communication between scientists and society using the currently available interactivity tools. This scenario creates new possibilities for innovation in the field, where several attempts have been made with new media products to fill this gap. Since the advent of the internet, society has been able to experiment with new ways to communicate and acquire information, available in larger volumes and with greater speed, and readers and viewers can participate more in public debates and content production.

The public is not a passive recipient in this communications circuit, but an actor with an active voice, able to contribute to the exchange of knowledge. In this context, communication is never a natural practice, but the result of negotiation. That is why simply providing the information is not enough to communicate. Communication is not just about free and equal groups sharing common

viewpoints, but about organizing coexistence between often contradictory worldviews.

According to Su, Akin et al. [2015], communications media provide the public's primary sources of scientific information. More and more individuals rely on digital media or online environments to find scientific information. Brossard [2013] adds that the news is being transmitted in novel ways, with new formats and new contingencies, including hyper textuality, connectivity, interactivity, and multimedia (videos, text, images, and others.). Kouper [2010] states that today's internet is part of science communication and stresses the importance of familiarity with such media's roles.

The use of new or digital media requires adapting to new formats and narratives. Peters et al. [2014] discuss whether communication via new online media is a genuine transformation or a new outfit for old models (newspapers, magazines, radio, and TV). He adds that not all online communications differ conceptually from traditional ones and that many digital media use these new features without modifying "classic" communications.

A recent survey on Public Perception of Science and Technology (S&T) in Brazil [Centro de Gestão e Estudos Estratégicos, 2019] showed that while many Brazilians lack the habit of informing themselves on science, those who do have this habit search for information through such media as the internet, social networks, and TV shows. They also reported their use of search engines, Facebook, and YouTube to find S&T information. A study of the U.S. population found that digital media are the main sources of scientific information for this audience [Su, Akin et al., 2015]. Brossard [2013] also reports that science communication increasingly takes place through blogs and other online-only forums.

One of the key objectives for digital media products is to be "interactive". But what does interactivity mean? Researchers have defined interactivity in several ways, and those definitions are extremely diverse and inconsistent [Kiousis, 2002]. Most frequent definitions are (i) a property of the media [Sundar, 2009]; (ii) a perceived feature [Sundar, 2009; McMillan, 2002]; or (iii) a context in the message exchange [Rafaeli and Sudweeks, 1997]. Kiousis [2002] tried to accommodate all perspectives within a single definition that also allows for a pragmatic use of this definition in research. To measure the degree of interactivity, one should measure the connectedness of one message to the other. However, for a fully interactivity environment, one should also consider the perception of the users and the outcomes of the processes.

Barry and Doherty [2017] studied the possible meanings and uses of the word interactivity and found out an extensive use of interactivity linked to the concept of empowerment. In that context, they formulated a model of interactivity for empowerment "through the actions, context, strategies, and outcomes of interactive communications". In this paper, we will use interactivity as an activity that 'enables' action, 'allows' access, or 'offers' possibilities, choices, or opportunities for communication. It then creates the potential to change the content and roles of participants.

The current study analyzes a novel interactive initiative by *Ciência Hoje* (Science Today) magazine, the Interactive Article. Our study aims to investigate how users

(readers of the magazine and authors-researchers) report on this new interactivity initiative. For this, we analyzed the comments of the readers, the intensity of participation, and how the researchers/authors perceived the initiative.

Ciência Hoje magazine and interactive articles

Ciência Hoje is a science communication magazine in Brazil that serves as a bridge between Brazilian researchers and the lay public. It provides an overview of science output by universities, institutes, and research centers [Queiroz and Abreu Ferreira, 2013]. A distinguishing feature of this magazine is the presence of scientists on the editorial board [Abreu Ferreira and Queiroz, 2011]. Unlike many other popular science magazines, all its articles are written by scientists and peer-reviewed. However, all articles are reviewed also by science journalists, who edited the texts to make them more accessible to the public. This editorial process has been essentially unchanged since its first edition.

The magazine, first of its kind in Brazil, has been published since 1982 targeting adults and teenagers without scientific training. In 1986, the magazine began to publish a folder targeting children (from 7 to 12 years old), called *Ciência Hoje das Crianças* (Science Today for Children), which became a publication of its own in 1990. Both magazines have used virtual platforms for a long time, but mainly as a complement to the printed material. *Ciência Hoje* magazine launched a BBS (Bulletin Board System) in 1993 that became a web site in 1996. Since 2009 the magazine holds a Twitter account, now with more than 80000 followers, and since 2010 a Facebook page, currently with more than 900000 followers and likes.

In 2018, a new model to produce science communication articles was proposed, namely 'interactive articles'. This new format was designed by the board of the magazine while rethinking the whole editorial model for the relaunch. It was intended to create a new model of an article that was more accessible and interesting for the readers. The current paper describes and analyzes this novel initiative.

Collaborative text construction is not a new thing on the internet. Wikipedia is a successful example of collaborative construction with no clear authorship [Giles, 2005]. In science publications, the authorship is an important feature; most of the collaboration is related to an open-peer review of the paper and post-publication improvements [Ross-Hellauer, 2017]. The collaboration proposed in the 'interactive articles' occurs before the article is written, so they are intended for the authors to debate with non-specialized readers to consent which discussion is more relevant, and what others types of knowledge should be taken in account. In that sense is quite different from previous collaborative initiatives such as wikis and open-peer review. In a non-systematic survey of over 41 international popular science magazines, we found no similar feature, nor even regular channels for interaction between the readers and the articles' authors.

Ciência Hoje's editorial board invites authors to write interactive articles. Those invitations are discretionary, mainly defined by subject (if it is going to spark a good interaction or not) and author profile (if it is someone that is going to be able to deliver fast feedback online and engage in conversations). They are asked to begin by producing a short paragraph and a one-minute video inviting readers to

collaborate in the article. The video is posted on the magazine's webpage with the theme and link, plus the explicit information that it is an interactive article.

The video is expected to attract readers' attention, urging them to provide their opinions and asking provocative questions. Interactivity between researchers and readers takes place in an internet forum. The video is open to interactivity on the magazine's website for three to five days, after which the first step in the process ends. To access the interactive article, it was not necessary to log in, just watch the video and comment on it within the magazine's webpage — the user was required only to give a name to comment.

In addition to publication on the magazine's website, there are posts on the magazine's Facebook page. These are not limited to videos, but have invested in several e-flyers — usually, a background image with a simple sentence, usually a question to draw people's attention, and a link to the website.

The authors then have a month from the date of posting their videos to prepare an article based on the interactivity on the webpage. The finished articles, edited by the magazine, are published in the subsequent month's edition.

To study how this novel interactivity initiative in science communication worked in six months in the first year, we analyzed the interactions between the authors and readers and the authors' perceptions of this new experience.

Materials and methods

This research investigated how traditional media, a science communication magazine, can incorporate a new perspective to be more user-centered, to enable dialogue, and to engage its readers in science discussions. This analysis is centered on a new initiative of *Ciência Hoje* magazine called 'interactive articles'. We investigated how this novelty was perceived by the magazine's authors and how it was used by readers and authors, in terms of its interactivity and empowerment.

The main research strategy was methodological triangulation, a mixed-method form of evaluation as an investigative technique and strategy in social programs and projects [Knafl and Breitmayer, 1991]. The methods used were both quantitative and qualitative.

We analyzed the comments on both platforms, namely the magazine's website[1] and its Facebook page.[2] The magazine did not explicitly intend to produce interactivity on the Facebook platform. Only advertising was posted on Facebook. Readers' comments in the commentary space were answered by the editorial board, instructing readers to interact via the magazine's website. However, since readers sent questions on Facebook anyway, we collected and analyzed them.

Brazilians are strong users of Facebook social media, being the fourth-largest number of users. Facebook is not only social networking for the population but integrated into almost all aspects of daily life [de Oliveira, Huertas and Lin, 2016]. About 93% of internet users in Brazil have a Facebook account.[3] Although the

[1] http://cienciahoje.org.br/.
[2] https://www.facebook.com/cienciahoje/.
[3] Data available at https://www.internetworldstats.com/, retrieved on April 7th, 2020.

magazine has not planned to use it for interaction with the readers, the reality of its usage by the population imposes itself. All publications from *Ciência Hoje* are in Portuguese, both on Facebook and on the website. All the comments collected were in Portuguese, only the ones quoted in this paper were translated.

The analysis was based on 12 interactive articles published in *Ciência Hoje* (two publications per month) from August 2018 to February 2019. Comments were analyzed according to the number of comments per article, the number of questions with and without answers from the authors, and the number of interactions with readers (if any). Content analysis was based on Bardin [2013] and Kouper [2010]. The following were evaluated: contributions to the topic (reports, arguments, explanations, or clarifications of questions), deviations from the topic (digressions, insults, or self-promotion), expression of attitudes and emotions (approval/disapproval, gratitude, regrets, or shared personal experiences), and attempts to influence the actions of others (advice, recommendations, requests, or proposals).

The categories were not exclusive for each comment, a comment can be two or more categories. The coding was done only in categories level ('Contribution to the topic'; 'Deviation from the topic'; 'Expression of attitude and emotion'; and 'Deviation from the topic'), the subcategories were used only as a strategy for coding. The only subcategory that was coded was 'insults' within the category of "Deviation from the topic", for a specific analysis. Two people were involved in categorizing the comments and when there was disagreement the doubt was reassessed until reaching a common choice.

After editing and publishing the interactive articles in the online magazine, seven authors were interviewed. We only interviewed authors whose articles had been published no more than a month before, i.e., authors of interactive articles published in the online magazine from October 2018 to February 2019. Interviews were conducted by telephone or on WhatsApp and transcribed afterward. The script consisted of eight questions to understand how the authors perceived the new initiative and whether their final articles had changed because of it.

The answers were analyzed by the two authors of the present article, using the collective subject discourse method (DSC) [Lefèvre and Lefèvre, 2014], using tabulation and qualitative data organization, based on the theory of social representation. The method sheds light on a collective group's thoughts, representations, beliefs, and values on a given theme. Within this method framework, all subjects' discourses are broken down on central thoughts that represent socially shared narrative codes. The discourses are then reorganized to represent those collective stories rather than individual thoughts, that is, the collective representations of what is being asked. All interviews were conducted in Portuguese and transcribed and analyzed in Portuguese, only the collective discourses were translated to English

Results and discussion

(A) analysis of the comments

In the sample of 12 interactive articles (Table 1), we collected 162 reader's comments on an internet forum on the magazine's website.

Table 1. Science field and number of comments on *Ciência Hoje* magazine website for the analyzed interactive articles (only comments from readers).

Science fields	Theme	Number of Comments
Exact and earth	Flat earth	7
Exact and earth	Coastal erosion	8
Exact and earth	Dark matter	9
Biological and health	Breastfeeding and infant health	6
Biological and health	Games and health	9
Biological and health	Aedes control	11
Biological and health	Anti-vaccination movement	14
Human and social	Fake news	9
Human and social	Public perception of S&T	9
Human and social	Altmetrics	10
Human and social	Nonpartisan school	15
Human and social	Affirmative action	55
	Total number of comments =	162

Did readers comment on some articles more than others? The number of comments posted by readers in the website's forum varied considerably from one theme to another (ranging from 6 to 55 comments per article). When grouped by field of science (exact and earth sciences, human and social sciences, biological and health sciences), articles in the human and social sciences showed the highest mean number of interactions per article (Table 2).

Table 2. The average number of comments on the *Ciência Hoje* magazine website by "Science fields".

Number of Articles for field	Science fields	Average of interactions by articles by science field	*Standard deviation*
3	Exact and earth	8	1
4	Biological and health	10	3
5	Human and social	20	20
Total = 12	Average of interactions by article = 14		

Importantly, the analysis found some socially appealing subjects within different 'fields'. In Table 1, the 'Anti-Vaccination Movement' in the field of biological and health sciences displayed the most interactions, with 14 comments. The theme 'Affirmative Action' in the field of human and social sciences received more than fifty comments. For themes in the exact sciences, no themes received more than ten comments. Thus, the greatest interactivity occurred in subjects circulating more widely in the traditional and digital media when the videos were posted.

How often did authors interact with readers? As for the authors' participation in the interactions (responses to readers' comments), 34% of the comments were not answered by the author (Figure 1). However, the largest proportion (83%) involved comments made outside the 3–5-day interaction period determined by the magazine, and the smallest proportion (4%) involved comments limited to

supporting messages. Thus, we can say that in most cases the authors interacted extensively with the readers. In various cases, the thread had several exchanges between authors and readers. Readers also interacted with each other, commenting on other questions and arguments.

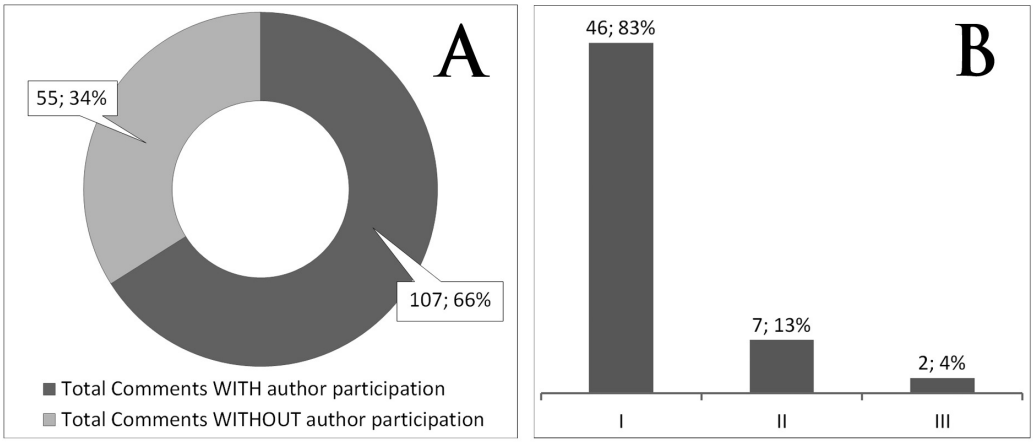

Figure 1. A. Proportion of author interaction with the readers. B. I — Comments not answered by authors after the interaction period ended; II — Comments not answered by authors during interaction period; III — Comments only with expressions of satisfaction or disapproval.

What was the content of the comments? Readers interacted and posted comments on all proposed topics; therefore, the interaction worked in the various situations we studied. It is important to note that a single comment can be (and generally was) included in more than one category. There were cases, for example, in which a comment or sentence contributed to a topic with a 'report', but in a later sentence it deviated from the topic at hand with 'self-promotion'.

Comments on 'Contributions to the topic' occurred most frequently in the 12 themes (Table 3). When the topics did not reach 100% of the comments posted with contributions, it was because there were some without relevant new content. Examples of this category can be seen on the 'Flat Earth' forum: "just travel by plane in the window seat and you will see the curve of the planet."

The category 'Deviations from the topic' appeared only a few times, in seven themes. For example, on the 'Affirmative Actions' theme, these comments occurred: "You have the two best friends in the world".

The category 'Expression of attitudes and emotions' was highlighted in most posts in the human and social or biological and health sciences, with the sharing of personal experiences. The comment on the topic "Breast Feeding and Infant Health" is an example: "My baby is 10 months old and I breastfeed on demand. I intend to let him breastfeed if he wants, but my question is the same as…, as how to know that the liver and other organs are already mature enough?!". This example is also useful to demonstrate how a comment could be placed in two categories, 'Expression of attitude and emotions' and 'Contributions to the topic' by asking a question pertinent to the topic.

Table 3. Percentage of comments from magazine website that were 'Contributions to the topic'; 'Expression of attitude and emotion'; 'Attempting to influence the actions of others'; or 'Deviations from the topic'.

Theme	Contributions to the topic	Expression of attitudes and emotions	Attempts to influence the actions of others	Deviations from the topic
Flat earth	100%	57%	71%	14%
Coastal erosion	88%	63%	50%	13%
Dark matter	100%	0%	78%	11%
Breastfeeding and infant health	100%	83%	50%	17%
Games and health	89%	33%	78%	11%
Aedes control	100%	36%	55%	0%
Anti-vaccination movement	100%	64%	43%	0%
Fake news	100%	78%	100%	0%
Public perception of S&T	89%	89%	67%	11%
Altmetrics	80%	40%	10%	0%
Nonpartisan school	100%	80%	67%	0%
Affirmative action	95%	84%	71%	7%

The category 'Attempts to influence the actions of others' was seen particularly in the theme 'Fake news', since all comments added recommendations, proposals, and requests, such as "Talk about articles that say that the greenhouse effect does not exist" Not only did the fake news receive a lot of media attention, but the author's speech in the video strongly invited readers to contribute in this direction.

How did the readers comment, share, and react to the posts about the interactive articles on Facebook? To evaluate Facebook posts in interactive articles, we collected 276 comments made on 27 posts linking to the 12 interactive articles. We divided the posts into two categories: publication of interactive articles in video format (12 posts) and publication of interactive articles in e-flyer format (15 posts). These formats are used as an advertisement piece for interactive articles, appearing on the Facebook users' news feed to invite them to participate in the forum within the magazine's website.

We compared the reactions (likes, loves, laughter, sadness, and anger) with the shares in both formats (video and e-flyer) through the analysis of Spearman's correlation coefficient (ρ), which measures the intensity of the relationship between the variables, including for non-normal data. Then, we observed positive correlations ($\rho = 0.65$; $p = 0.01$), therefore, the videos and e-flyers that had more "reactions" also had more "shares".

Comparing all the themes of interactive articles published in video format with those in e-flyer format, on average, videos were shared more e-flyers, and reactions were more frequent in e-flyers than in video publishing. (Table 4), even with a relatively high standard deviation.

Table 4. Average number and standard deviation of shares, reactions and comments from Facebook.

		Average	*Standard deviation*
Video	Shares	38	21
	Reactions	57	21
	Comments	6	4
E-Flyer	Shares	25	12
	Reactions	81	40
	Comments	17	21

We understand that comments, shares, and reactions represent different scales of participation or public engagement on Facebook. Thus, the reactions represent the popularity of the publication or the pages, the actions (shares) work more like approval and the comments are a scale that better indicates the level of participation [Agostino and Arnaboldi, 2015].

To have a baseline for comparison, we collect reactions, shares, and comments for other magazine's post on the Facebook page during a single month.[4] For posts that were not linked with the interactive articles (e-flyer for regular articles, special news, celebration posts, etc.) we observed a mean value of 89 reactions, 41 shares, and 7 comments. However, a single post in that month went viral and received alone 355 reactions, 229 shares, and 29 comments. If we remove that post, we observe a mean value of 57 reactions, 22 shares, and 4 comments. What we observe is that interactive article posts on Facebook received similar metrics in terms of the popularity of the posts. But if we consider metrics that are more related to public engagement, the e-flyer posts for an interactive article are more effective in providing a dialogue with the public on Facebook.

Where did readers comment most? When comparing the intensity of readers' comments according to themes on the two platforms and posting formats, all subjects received more comments on the magazine webpage and in e-flyers on Facebook (Table 5). This highlights the need to explore different media formats and models. Although it is not possible to determine which model engages more readers, one can deduce that all three have the potential to attract readers' participation.

Table 5. The average number of comments in thematic fields by different media formats.

Science fields	Magazine	FB_video	FB_*E-Flyer*
Exact and earth	8	4	10
Biological and health	10	6	17
Human and social	20	8	21

We compared the numbers of comments posted on the magazine's website and Facebook page, by theme. Most themes attracted more participation by readers on Facebook, however, a large proportion of these posts were only friend tags. The themes that attracted more comments on the website were 'Coastal erosion',

[4] 11 posts published in July 2018.

'Anti-vaccination movement', 'Fake News', 'Public perception of S&T', and 'Nonpartisan school' (Figure 2).

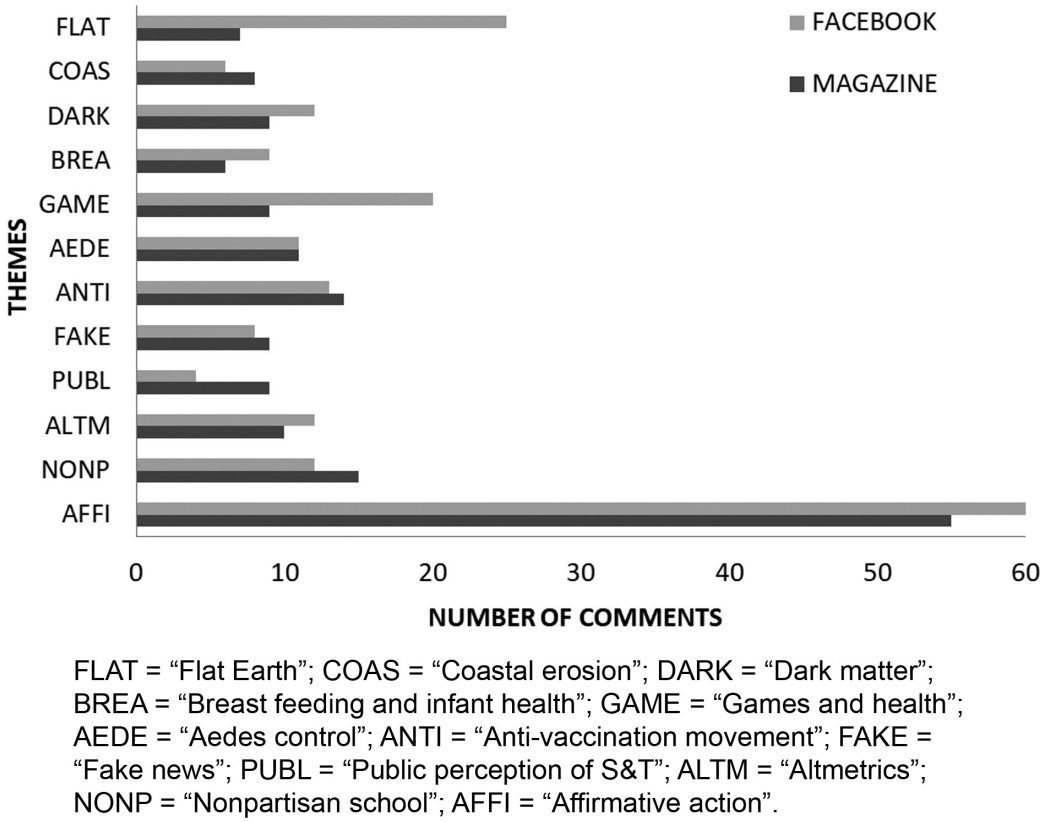

Figure 2. Comparison between comments from the magazine website and Facebook page.

However, quantity is not synonymous with quality. Most of the themes showed more deviations from the topic on Facebook. Many comments classified as deviations from the topic involved digressions and insults. Thus, the presence of insults is shown in Figure 3. Interestingly, themes on the magazine website also included deviations from the topic (Figure 2), but no insults. That may be due to the broader exposure that the topic has on Facebook since those topics were frequently subject to ideological disputes. Examples of such behavior can be seen in one comment left on a Facebook post about 'Affirmative Action': "Two things I am against; affirmative actions and ignorant people like you".

When comparing how much the participants wrote, that is, how many characters in each comment, we believe that we can observe how much they dedicated themselves to interaction (Table 6). The article 'Nonpartisan School' received the second greatest number of comments and the biggest size of comments on the website. Therefore, this controversial article was the one that most caught the attention of readers. Posts on Facebook, however, were more numerous but far smaller than the ones left on the website.

Peters et al. [2014] report similar findings, with greater interactivity and participation on Facebook, but not automatically leading to improvement in public

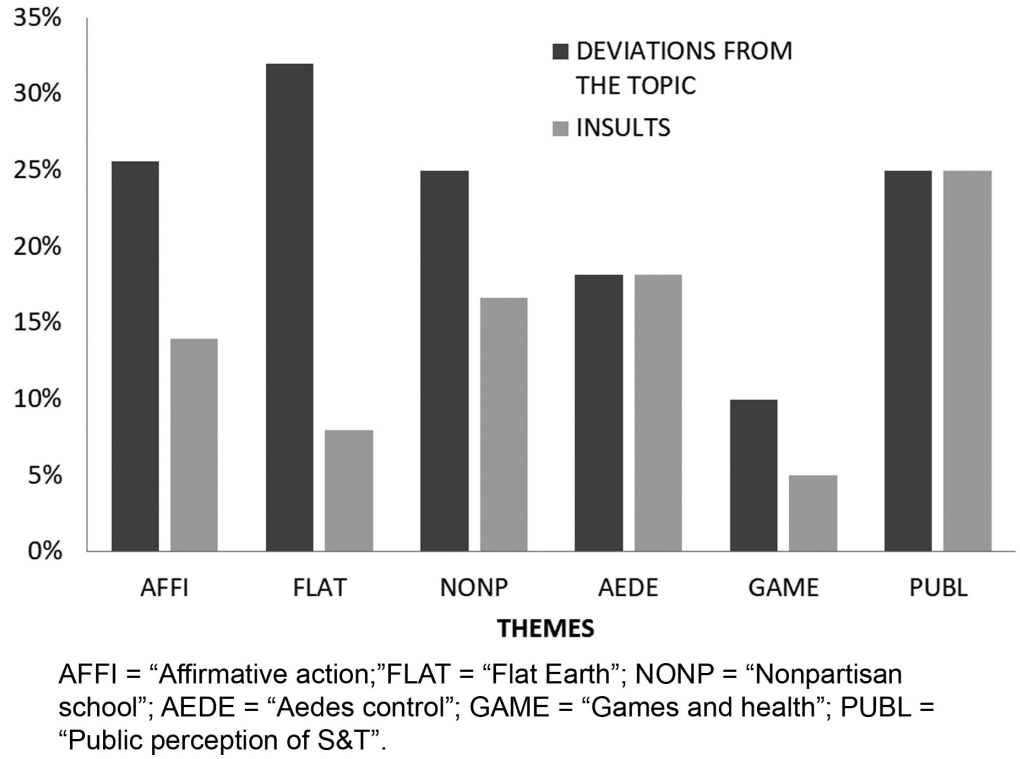

Figure 3. Number of comments with deviations from the topic (change of theme, insult, or self-promotion) and the number of comments with insults, from the Facebook page.

Table 6. The average number of characters in comments from both website and Facebook.

Theme	Authors	Readers (Magazine)	Readers (Facebook)
Flat earth	568	627	138
Coastal erosion	947	442	142
Dark matter	1850	390	350
Breastfeeding and infant health	347	535	251
Games and health	486	307	91
Aedes control	394	320	103
Anti-vaccination movement	405	396	262
Fake news	228	668	225
Public perception of S&T	256	782	165
Altmetrics	1559	560	104
Nonpartisan school	1521	1023	193
Affirmative action	493	583	149

dialogue. Their study reported on an experiment that studied the effects of comments on readers' perceptions of science, demonstrating the risk of bias in perceptions when readers were exposed to rude comments from other readers. The magazine they analyzed (Popular Science) thus decided to eliminate readers' comments, arguing that they can disrupt the discussion rather than helping it. In Hsueh, Yogeeswaran and Malinen [2015], participants were exposed to biased

comments from an online article, influencing respondents to post more biased content, presenting social changes in the online environment. Su, Xenos et al. [2018] conduct an extensive study on uncivil comments of U.S. news outlets and showed that it ranges from 20% to 40%, but it varies a lot depending on ideological content and coverage. A recent study of the reader's comments on a Serbian news site [Đorđević, 2020] showed that hate speech is frequent and that reflects the negative impact of news on the interface between discourse and society. However, Yeo et al. [2019] showed that non-civil comments on online news articles on science and technology issues lead to biased interpretations of the content, but it is possible to alleviate the effect by using a moderator.

When comparing the content of readers' comments on the website and Facebook, 'Contributions to the topic', 'Attempts to influence actions by others', and 'Expressions of attitudes and emotions' were more frequent on the magazine website (Figure 4). Thus, in this study, Facebook did not prove to be a good vehicle for dialogue, since it made fewer contributions to the discussions, more attempts to influence other readers with advice, fewer cordial comments with approvals, disapprovals, or personal reports, and even more deviations from the topic at hand.

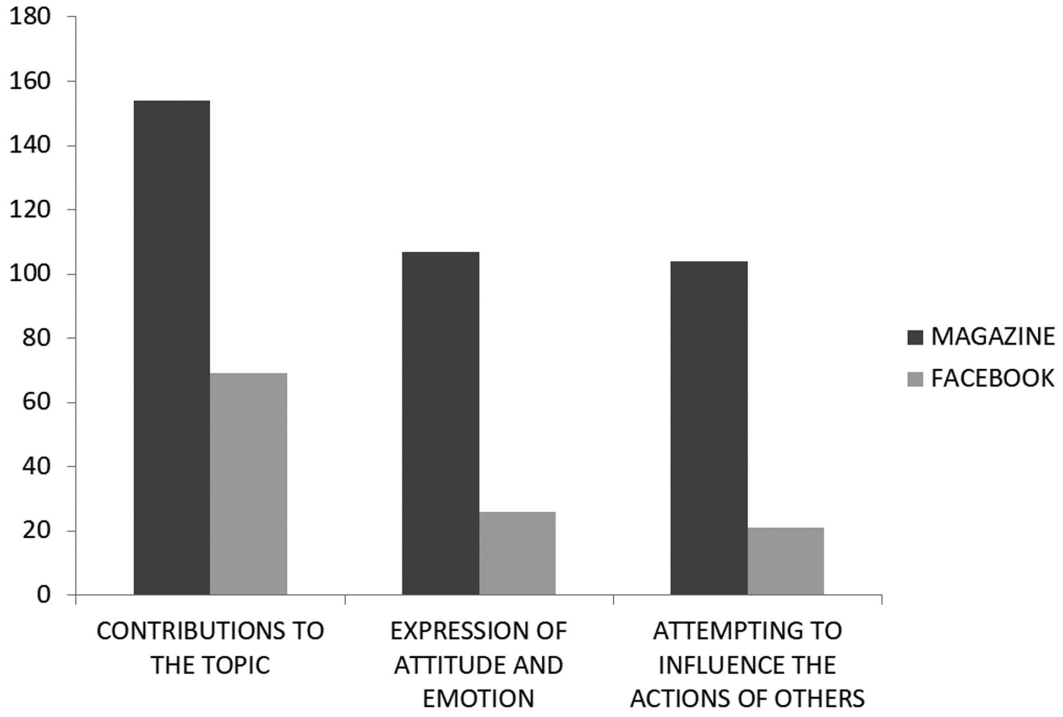

Figure 4. Number of comments in both magazine website and Facebook page that Contributed to the topic; Attempted to influence the actions of others; Expressed attitude and emotion.

The online space in forum style created on *the Ciência Hoje* magazine website showed positive results for interactivity with readers according to Barry and Doherty [2017]. There was mutual and simultaneous activity by participants (readers and authors), working towards the same goal, namely, to discuss the themes to produce content and a more reader-directed article. The result was viewed as a collaborative output, creating a social environment with cordial and constructive relationships.

(B) interviews with researchers-authors

How did the authors perceive the tool's action (interactive article) on their work? Did this form of textual production impact the result of the interactive article? Those were the main questions that we asked the authors The discourses gleaned from the interviews revealed the authors' perceptions of readers' interaction with their writing, including whether this form of text production had changed the final product. Their answers showed great acceptance of the proposal and optimism on the creation and use of this innovative approach to science communication and that they were interested in using models that prioritize understanding their readers' curiosities and doubts.

Four major central ideas were attributed by the authors to the interactive articles: Innovation; Closeness; Contextual model; and Co-authorship. The collective discourses presented below were organized from these central thoughts obtained by the CSD method using parts of the interviews.

Innovation. According to Hargie and Tourish [1996], innovation is a social, symbolic, and technological phenomenon, permeating the entire field of communication. This concept is attributed to the novel communication tool of *Ciência Hoje* magazine by the following discourse:

> *In my view, [the interactive tool] is a very innovative thing. I had never participated in this interesting format for article writing and had never seen it before in any kind of magazine, where you can anticipate questions like, "Look, there is going to be an article [on this topic], so voice your questions!" I think this interaction transcends both the print magazine and the online magazine, where it has been only one-sided, from the paper or the screen to the reader. This article was a new experience for me, and I also think it must have changed the writers' way of writing. So, I think it is an important path for us and it is a path with no turning back because we have seen it in different media, on different platforms.*

Closeness. According to Burns, O'Connor and Stocklmayer [2003], science communication should establish a dialogue by calling on lay people to engage in debates on science. This approach with readers can also add bilateral relations, enriching the acquisition of knowledge, and broadening the ways science is viewed from various angles. The following collective discourse show just how important this experience has been:

> *In producing the article, I had to use examples that would clarify my theme, because I truly believe that in a science communication article, practical examples are key to achieving the goal of reaching a broader and perhaps more lay audience with the theme. It is a way for us to come closer to what potential readers want to know, to draw closer to the real world. Overall, it was good to see that people had questions and wanted to debate and shed light on issues. [They wanted to] talk about the knowledge that may have been established for several decades, but it was important to motivate them and not proceed directly to a more advanced stage. It is relevant for science communication to share with society at large what is being done and discovered, to say, "Look there is scientific thinking, a scientific way of thinking, and people are missing it!". I think it also helped to have the confidence to answer commonsense questions and think that a historical issue can be an issue of national relevance and a thing of interdisciplinary importance. So, I think this experience is great, with interactive articles as a form of interaction with readers.*

Contextual model. According to Miller [2001], modern science communication is part of the contextual approach, where scientists have scientific facts available and members of the public have local knowledge and interest in problems that require solutions.

Learning about the magazine's readership and cooperatively building a communication product through two-way interactivity between scientists and readers in an online platform generated several important experiences for the authors. The following are some examples of experience with the contextual model on the *Ciência Hoje* website.

> *This experience gave me a small sample of what I could expect in terms of readers' expectations and prior knowledge. Of course, the people who went there and commented did not necessarily have the same thinking as most of the magazine's readers, but they were the ones who expressed their views. I assumed that this was the case, so I tried to respond to the people that interacted. It is important to listen, to learn what they know and what they want to know, the people for whom you write and speak, to practice more effective communications. This helps the author write increasingly readable papers, in detail, to be more direct, emphatic, clearer, and more relevant in the context of sciences as applied to the population. This gives you an idea of who is on the other end, making the product much more complete, much more intelligible, extending the reach of science. I had an initial view focused on the most contemporary things in the field, but in fact, most readers' questions were more basic. But they raised a lot of valid questions, so the interactivity made me a little more grounded in the sense of addressing issues that are familiar to the field but not known to the "lay public". This all greatly enriched the way the article was written. It was a nice way of building because it was very lively due to demand. I am certain that the final article was more fluid, more interesting, with a focus on readers' interests and curiosities, a "less scientifically selfish text". It was very important for me to be able to translate my research into points that may be much more interesting for [other] people than for me, but which have now become more interesting for me as well. Thus, the only way for science communication to play its real role in a democracy is to be a communications channel that is not limited to throwing more information into the loop but is trying to tie join with the public and empower them, to hear their needs and build trust.*

Co-authorship. The exchange of knowledge between scientists and the lay public can spawn many discussions, especially when producing an article together. The interviews with the authors showed that the call for readers' participation resulted in co-authorship of articles. This feature draws on the public engagement model, seeking to increase public participation in the discussion of science without necessarily controlling ideas [Lewenstein and Brossard, 2010]. According to Brian Trench [2008], such an exchange can be a more effective way for readers to express concerns, raise questions, and engage more actively in issues arising in scientific knowledge. The co-authorship outlined by CSD below thus involves engagement, according to the participants:

> *I always say that I worked as follows: when the interaction period was over, I printed out all the readers' comments and my answers, grouped key questions that were close to each other, that displayed related themes, and built the text based on those questions. In this tool, the author launches a theme, and lets it shape the narrative, shape the content through people's questions. I think the reader's view of the work is interesting and sheds light on points that I might not have considered important otherwise. In a way, this helped me understand my work. Some people said it was important to have*

discussions on truths, even if they are well established, raising questions that I hadn't thought of addressing. It is also an opportunity to publish stories before they are written, and especially to engage and motivate future readers to contribute to the story and to feel they are part of the process as well. In a way, readers see themselves as authors of the study, participating with questions, knowing that their questions will guide the article's genesis. So, I am certain that this greatly increases the population's engagement with science, drawing the public closer. Importantly, it is still a very restricted audience.

Conclusion

The study indicated that this new communication initiative, the interactive article, was successful with readers and obtained support from several authors, with compliments and suggestions for improvements. It involved the characteristics of "public engagement" and "contextual" models of science communication, as discussed by Lewenstein and Brossard [2010], since interaction with readers was used as a contribution to the future articles, leading researchers to reflect on their scientific fields, besides considering the specific characteristics of the target audience. More specifically, interactive articles took shape according to the readers that interacted in the activity.

The authors achieved a high degree of interactivity with readers. The few moments of absence were justified by a minority of clearly irrelevant comments. More than a specific field of science, what we observe is that the topics that attract many political and ideological debates, those that are highly polarized, were the ones that most engaged. Thus, we can infer, as contemporary scientific communication indicates, that the population is more involved in discussions on scientific topics more related to their lives and that they mobilize political ideologies and passions.

When evaluating interactions involving posts on the *Ciência Hoje* Facebook page, there was a pattern in all interactive articles, with more reactions than shared actions and, lastly, commenting actions. When comparing shares across all posted topics, there were more shares on average for videos than for posts with e-flyers. However, the latter showed more reactions and comments than video posts. There were interactions in the two platforms (the magazine's website and its Facebook page), showing that different media formats have the potential for interactivity.

In the analysis of interactive comments on the magazine's website, all the themes showed positive interactions. There were numerous 'Expressions of attitudes and emotion' with the sharing of personal experiences in the human and social, biological, and health sciences and expressions of approval and disapproval in the exact and earth sciences. Comments with 'Attempts to influence the actions of others' were featured in the article on 'Fake News', in which the author invited readers to participate with contributions, recommendations, proposals, and examples.

We compared the interactive contents between the two platforms — there were more comments per theme on the Facebook page. However, the quantity was not synonymous with quality. Most comments on the Facebook presented 'Deviations from the topic', including numerous insults. Interaction on the magazine's website featured more 'Contributions to the topic', 'Expressions of attitudes and emotions', and 'Attempts to influence the actions of others'. Thus, in this study, the Facebook

platform did not prove to be a good vehicle for dialogue, since it conveyed fewer contributions to discussions, comments with smaller sizes, fewer cordial comments than those presenting approval, disapproval, or personal reports, and even more deviations from the topic.

The interviews with the authors expressed great acceptance of the proposal. This type of model favors various stakeholders, including the authors, their institutions, the media, and especially readers.

Finally, the interviews spawned reflections on contemporary challenges in science communication. Authors reflected on the subject, believing in the importance of interactivity as a productive communication tool and praising the importance of elaborating on ideas from readers and their development by scientists.

> *I think we need more interactive media, more channels to communicate the production by Brazilian science. Besides, if you cannot explain it simply, then you do not quite understand what you are doing. I consider this the crux of the issue in science communication. You must be able to develop a dialogue with the public, with the lay public. We need to invent ways of listening to our audience and do not presume what the public knows or needs to know. Not working from the top down; everything comes from bottom to top, from the public to the communicator. So, I think this format invented by Ciência Hoje was great for that purpose.*

The authors considered that this new initiative improves the printed article, making it more accessible, but also improve the public engagement, as the final product can be considered, according to them, co-authored with the readers that participate in the interaction. But did it change it? Can we compare articles wrote in traditional style and notice a difference? These are some important questions that can still be researched. Moreover, does the public feel part of this final product? We did not interview the public in this project, but this is also a very important line of investigation. What can be called dialogue in today's digital media models? What are the consequences of good interactivity and engagement in digital media for the real lives of these participants? We believe that these questions also require targeted research.

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