What Science-Related Topics Need to Be Popularized? A Comparative Study

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Abstract

This paper presents preliminary results of our study on the topics raising interest for popularization. We compared the queries issued from various online services, namely *ELI5* and *Yahoo!answers* forums, *ScienceX* and *The Guardian* science journalism articles' titles, queries sent to the French platform of scientific articles *ISTEX*, and an online survey we carried out. We obtained some valuable insights. Queries belong mainly to one of the following categories: (1) "how to … ?" and (2) "what is the best … ?". Thus, people outside a specific scientific field are mainly interested in how to solve their problems. These insights are especially valuable for content selection in the context of text simplification. For non-expert, the most important information is the application of an object (which problem can be solved? how to use this information/object?) in their everyday activity.

Keywords

Science popularization, topics, survey

1. Introduction

With a constantly growing amount of information, summarization is of increasing importance. It is already a step towards text simplification as it reduces the amount of information to be processed. However, a summary designed for a scientist from a specific field should be different from that adapted for the general public. One of the main problems of scientific publications is that they are difficult for people outside the domain and so they do not read them at all. Moreover, the research papers are not written for the general readership. One of the solutions is the popularization of science and scientific journalism according to one of UNESCO's oldest programs [1]. In scientific journalism, "journalists serve as intermediaries presenting analyses to the public, but they must also provide the public with the means to reproduce their analyses" [2]. Thus, scientific stories include primary sources allowing readers to verify a document's information. In contrast to newspapers limited by the size of the page, digital technologies provide essentially unbounded capabilities for hosting primary-source documents. While science

journalism focuses on recent scientific research, popular science scope is broader. Science may be popularized by professional journalists or by scientists themselves in forms of books, films and documentaries, articles, and blogs. The popularization depends on a target audience of the publication or presentation. Nevertheless, an audience always prefers to be introduced to a new scientific achievement through a short simple text, which is well structured and free of any complex terminology. There is a point to developing the SimpleText project [3].

In this paper we tried to analyze the scientific topics that potential participants would find interesting and worthy to be popularized. To this end, we need to compare topics raised by ordinary readers, science popularizers and researchers. The research questions are:

- (RQ1) What scientific topics attract attention of the general public?
- (RQ2) Do the attractive topics match the categories that are described in popularizers' articles?
- (RQ3) What scientific topics potential researchers consider useful to popularize?

To the best of our knowledge, this is the first analysis of interest of science-related topics for popularization. The undertaken study is described in the next section.

2. Materials and Methods

The topics selected by the general public are obvious in datasets of queries from various forums, where users come to find information relevant to their everyday routine. Sometimes people need to understand chemistry to improve their cooking skills or game-theoretic approach in economics to choose a plan for savings. Keeping these objectives in mind, they avoid reading scientific papers and look for an explanation on internet forums such as *Explain Like I'm 5* (*ELI5*)[1]. Thus, we analyzed the queries issued from online services *ELI5* and *Yahoo!* answers forums[2]. As for someone, who searches deep understanding of chemistry to think out a treatment he/she receives, he/she probably prefers detailed information and various viewpoints that are available in *ScienceX* network[3]. Motivated users might be ready to dive into scientific research surveys and reviews. Therefore, we gathered collections and analyzed the queries issued from various online services. We add to the mentioned resources queries sent to the French platform of scientific articles *ISTEX*[4] in order to study the queries of users with different cultural preferences. Scientific popularizers write reviews and interview competent specialists for popular magazines and newspapers. To obtain the topics of these reviews, we gathered *The Guardian*[5] science journalism articles' titles. Thanks to these resources, we received a dataset of the queries of the general public and science popularizers.

Therefore, we deal with several datasets of queries and questions. At the first stage of our study, we aimed to answer (QR1) and (QR2). Firstly, we analyzed the queries issued from the following online services:

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[1]https://www.reddit.com/r/explainlikeimfive
[2]https://answers.yahoo.com/
[3]https://sciencex.com/
[4]https://www.istex.fr/
[5]https://www.theguardian.com/

1. Questions asked at the Explain Like I'm 5 forum *ELI5*.
2. Science journalism articles' titles from *ScienceX*.
3. Questions asked at *Yahoo!* question-answering forum;
4. Queries sent in 2019-2020 to the French platform of scientific articles *ISTEX*.

Nevertheless, our dataset lacks queries that researchers consider to be important to popularize. To cover the gap, we carried out a survey at the second stage of our study, aiming to answer (QR3). Our survey was created using LimeSurvey[6] platform and available in English and French. The link was shared via social networks and academic mailing lists. The participants were asked to provide at least 2 scientific topics interesting to them and related to:

- Computer Science;
- Climate Change;
- Health.

The content categories for the survey were chosen according to the results of the study of the topics of *ELI5* queries, the question-answering service *Yahoo!* answers materials and science journalism articles titles on *ScienceX*.

We asked users what scientific topics (e.g. computer science) they found interesting to popularize. To avoid "non-scientific" queries from the respondents, we provided some examples of answers. We are aware that the examples might to some extent frame our respondents' answers.

We studied the materials applying comparative, semantic and sociolinguistic analysis. We follow [4] recommendations on how to combine sociolinguistics and computational linguistics in the study of human behaviour and preferences.

3. Analysis of Science-Related Queries on Forums and in the ScienceX Network

3.1. General Description

In this paper, by a **query** we mean any research query or question in natural language formulated by a user of a given service. It may contain a whole phrase(s) or a list of keywords. As stated above, we analyse the queries issued from the following online services:

1. *ELI5*: the online forum Explain Like I'm 5 "for layperson-friendly explanations" (as the creators state it).
2. *ScienceX*: the network Science X brings together several websites to provide "daily coverage of science, technology, and medical news".
3. *Yahoo!*: the question-answering service Yahoo! answers by Yahoo!.
4. *ISTEX*: French-based search engine ISTEX of scientific articles.

All the datasets used in our analysis use mainly the English language, except for *ISTEX* that contains multiple entries in French.

Note that 530,840 over 1,222,700 queries in *ISTEX* were structured, e.g. :

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[6]https://www.limesurvey.org/

Table 1

Characteristics of the query datasets used in the analysis

dataset	period of time	# queries	avg. length of queries (# words)	inner categorisation	# categories
ELI5	2015-2021	228	14.25	✓	11
ScienceX	08.04.2014-22.02.2021	11,253	9.78	✓	60
Yahoo!	2018-2021	13,014	11.91	✓	26
ISTEX	01.01.2019-31.12.2020	1,222,700	8.35	X	0

Table 2

Example of queries by dataset

dataset	query
ELI5	eli5: Anabolic steroids stop mens own bodies from producing testosterone. Birth control pills stop females from producing estrogens. Why are estrogens safe to use for females but testosterones are considered unsafe to use for males?
ScienceX	Near-infrared imaging and machine learning can identify hidden tumors
Yahoo!	A guy coughed in my face in the street on purpose and told me he had the coronavirus. I can't get a test. What should I do?
ISTEX	l'énergie nucléaire en france[7]

```
title:"Traitement prometteur contre Alzheimer." AND
↪    author.name:"Casablanca, Liberation"
dentistry AND corpusName:(wiley) AND language:(eng OR ger)
dentistry AND categories.wos:("2 - dentistry, oral surgery &
↪    medicine")
```

The general characteristics of the datasets used for the analysis are given in Table 1. Examples of queries by dataset are provided in Table 2.

We perform the comparative analysis of the datasets with respect to the following aspects:

1. **Categories (topics)**: identification of the categories (topics) of the queries and comparison of their distribution among datasets.
2. **Frequent term distribution**: identification of the most frequent terms per dataset and comparison of their distribution among datasets.

3.2. Aspect 1: Categories

Figure 1 visualises the distribution of the categories within the datasets. Mind that we excluded *ISTEX* from this representation, as *ISTEX* does not contain inner categorisation (see Table 1).

We may note that the granularity of the categories varies among the datasets. Thus, the most coarse-grained categories can be found in *ELI5*, and the most fine-grained in *ScienceX*. The lists of the categories in *ELI5* and *ScienceX* are similar. Users of *ELI5* are mostly interested in Biology

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[7](French) nuclear energy in France

and Technology first of all. Users do not often appeal to this forum, they ask 32 questions per year; however, they prefer to enunciate their queries: an average query includes more than 14 words (see Table 1). The queries on *ELI5* reflect natural curiosity and reasoning when a user lacks knowledge to solve the problem (see Table 2).

ScienceX shows higher value of scientific knowledge in comparison with Technology. Technology occupies the 13th line in the list of *ScienceX* categories after natural Sciences and Neuroscience. The queries and the titles of the popularizers' papers contain scientific terminology (see Table 2) so the readership needs solid background to comprehend the articles. The collection of articles on *ScienceX* covers the area of *ELI5* queries. The network attracts many users who publish almost 1,407 queries per year. However, the *ELI5* users look for a short and simple text, which scientific journalism is not able to provide them with.

The category distribution in *Yahoo! answers* reveals that the user's area of interest includes travelling and entertainment first of all; users do not explore *Yahoo! answers* for searching scientific information. Those who look for precise and relevant explanations of scientific issues prefer *ScienceX*. Thus, the resources deliver the peculiar answers that users expect to obtain from the given forum or network. *ELI5* and *Yahoo! answers* give a chance to ask an original question and receive a short and clear explanation, which probably lacks scientific accuracy. Meanwhile, *ScienceX* shows a variety of topics and opinions. On *ScienceX*, the detailed information and fine-grained categories challenge readers. Populizers who write articles published in the network overestimate readers' preparedness to dive into the scientific mainstream.

3.3. Aspect 2: Frequent Term Distribution

Our second analysis deals with frequent terms. The results are depicted in Fig. 2.

We note the similarity between *ELI5* and *Yahoo! answers*, two datasets that target more the general public than *ScienceX*. Since these forums provide an analogue of a vivid conversation about the topic of user's interest, the frequent terms belong to the general lexicon of English speakers. The sets of the most frequent terms of *ELI5* and *Yahoo! answers* do not correspond to the scientific topics. The most frequent terms of the *ScienceX* are new, study, researchers, cancer, brain, cells. This set of the *ScienceX* frequent terms corresponds to the popular categories of this network (Biology and Neuroscience). Therefore, according to the sets of the frequent terms, the only source of scientific information is the *ScienceX* network.

4. Survey

We conducted an online survey on the topics that people find interesting to get popularised. The survey was available in English[8] and French[9]. We collected answers of 197 participants (84 complete and 113 incomplete answers). The survey was anonymous. Participants of our survey spent almost 15 minutes on average answering the questionnaire. The average time to answer the survey was 14 min. 34 sec. with the median of 10 min. 11 sec. The reported results are based on the complete answers only.
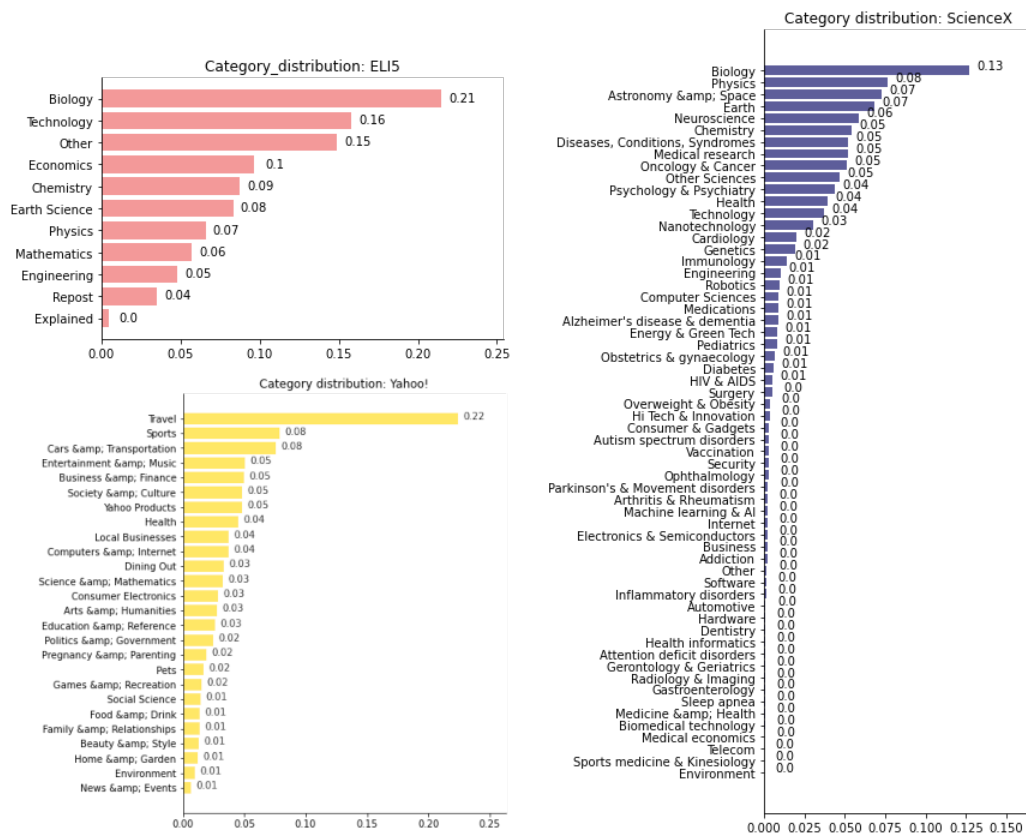
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[8]http://dsi-outils.insa-lyon.fr/limesurvey/index.php?sid=14118&lang=en
[9]http://dsi-outils.insa-lyon.fr/limesurvey/index.php?sid=14118&lang=fr

Figure 1: Category distribution, %

4.1. Participants

Most of the participants are university students and staff members; 51 of the subjects were males while there were 33 females.

The average participant is a 35-44 year old man with Doctorate Degree who is employed full time (see Tab. 3). The top-4 professional fields of the respondents are: Information Sciences and Technologies (39.29%), Engineering and Systems Sciences (14.29%), Humanities and Social Sciences (14.29%), and Biological Sciences (10.71%) forming 78.57% of the respondents.

32 of our respondents belong to highly educated people (Masters and Doctorate Degrees) in the field of Information Sciences and Technologies who are mostly FT employed. Taking into account twelve respondents, who claimed degrees in Engineering and Systems Sciences, and three representatives of those, who studied Mathematical Sciences, we are able to characterize half of our audience as highly educated professionals in modern technologies. Thus, our results represent the viewpoint of the intellectuals who understand the technologies and are aware of ordinary readers' interest in Technology.
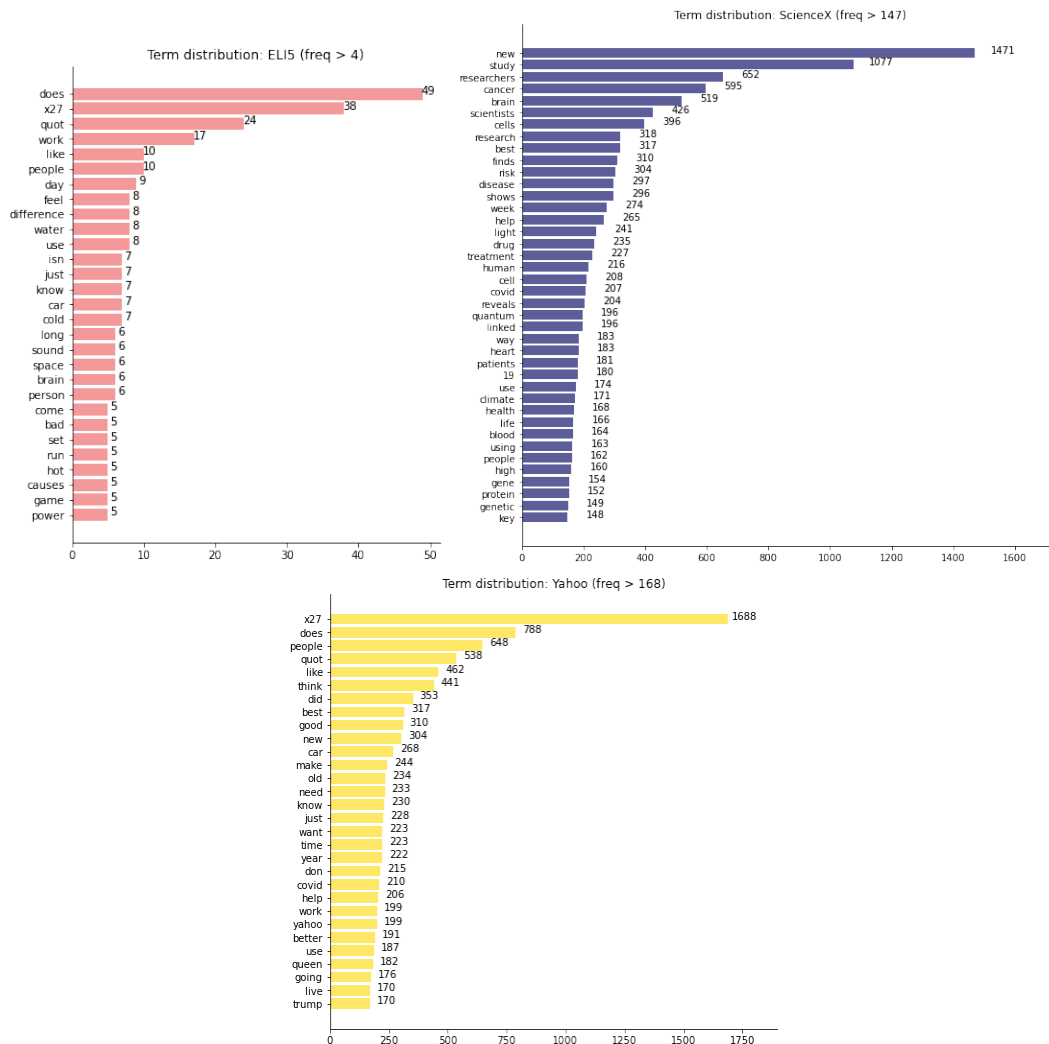
Figure 2: Term distribution: as the frequency threshold, 10% of the maximum term frequency within the dataset is used

4.2. Questions

The questionnaire includes general demographic questions (e.g. gender, age group, education, etc.). This part is followed by 3 main questions; each of the questions provide 3 text fields for answers (see description of the method in: [5]). The open questions belong to the scientific areas that the general public and popularizers consider interesting and attractive, namely Biology, Natural Science, Technology (Computer Science). We instructed the participants to think out queries in the areas of Computer Science, Climate Change and Human Health:

1. Please, provide 3 questions/topics that interest you in the field of *Computer Science* and that you consider as deserving to be popularised, explained better for a general public. Here are some examples: ethical issues of artificial intelligence, artificial intelligence

Table 3
Characteristics of the survey participants

Age		Education		Occupation	
Category	# of subjects	Category	# of subjects	Category	# of subjects
18-24	14 (16.67%)	I do not know	1 (1.19%)	Student	16 (19.05%)
25-34	23 (27.38%)	Gen. Certificate	5 (5.95%)	Empl. FT	55 (65.48%)
35-44	24 (28.57%)	Bachelor Degree	9 (10.71%)	Empl. PT	3 (3.57%)
45-54	16 (19.05%)	Engineering Degree	9 (10.71%)	Unemployed	5 (5.95%)
55-64	6 (7.14%)	Masters Degree	26 (30.95%)	Self-employed	2 (2.38%)
65-74	1 (1.19%)	Doctorate Degree	34 (40.48%)	Ret.	2 (2.38%)

    and freedom, quantum computing, green machine learning, data protection and privacy, augmented reality, smart city

2. Please, provide 3 questions/topics that interest you in the field of *Climate Change and Environment* and that you consider as deserving to be popularised, explained better for a general public. Here are some examples: nuclear energy and climate change, digital sobriety, hydrogen vehicles, NINJA generation, carbon footprint

3. Please, provide 3 questions/topics that interest you in the field of *Health* that you consider as deserving to be popularised, explained better for a general public. Here are some examples: covid-19 vaccination, 5G and health

    The first field (*Computer Science*) was selected as it belongs to Technology and represents the main research field of the SimpleText@CLEF workshop. The choice of the *Climate Change* field was dictated by the rising public concern, especially among students [6] and adolescents (see multiple initiatives like *The Shift Project*[10], *Marche pour le Climat*[11], etc.). Moreover, the integration of the sustainability topics into engineering curricula is one of the goals of the UNESCO Engineering Initiative (UEI)[12]. As for the last field (*Health*), it seemed important to cover given the COVID-19 pandemic context.

    At the end of the survey, the participants could provide additional scientific topics that interested them. Thus, we offered open questions and have been expecting explanations of the participants' choice.

4.3. Results

The *Computer Science* block counted 222 unique answers. Many questions of the participants are related to the topics of *Artificial Intelligence* and *Machine Learning*. The aspect of vivid interest deals with such issues as ethics and data protection. Participants also paid special attention to climate change related issues (*Green ML* and *Eco impact of technology* topics). Based on the answers, we have identified 33 topics and classified the questions by them. The classification was performed based on the inclusion of the identified key terms of the topics. Figure 3 depicts the popularity of these topics (some questions were assigned to multiple topics).

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[10]https://theshiftproject.org/
[11]https://www.greenpeace.fr/marche-climat-le-9-mai-pour-une-vraie-loi-climat/
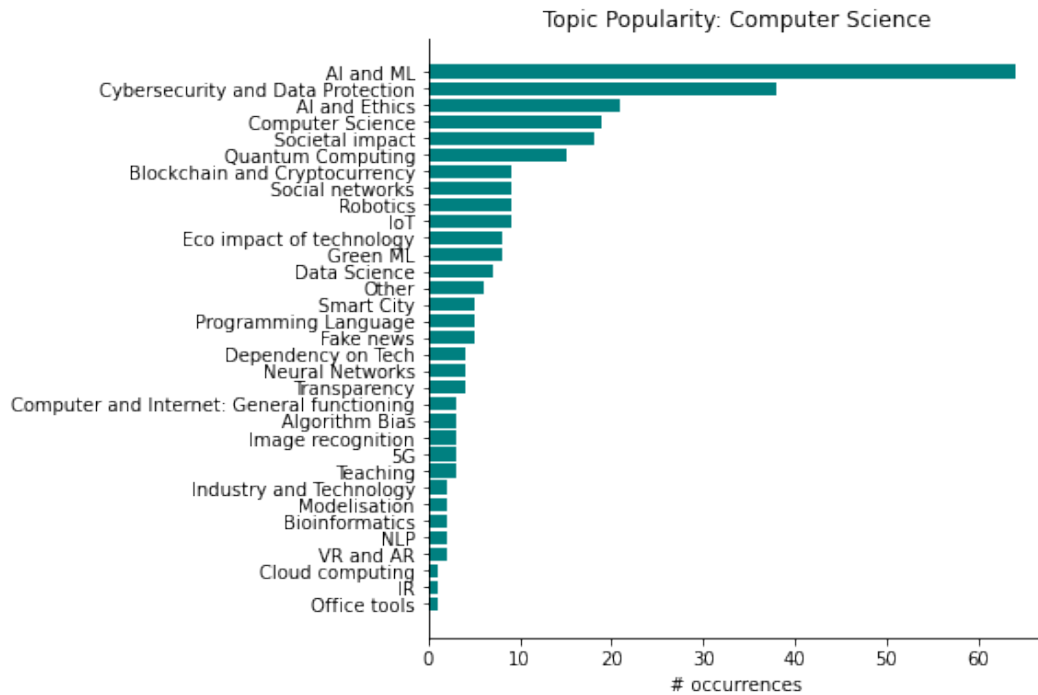[12]http://www.unesco.org/new/en/natural-sciences/science-technology/engineering/sustainable-engineering/

Figure 3: Topic popularity of *Computer Science* questions

The *Climate Change* block counted 224 unique answers. We identified 33 topics of interest (see Fig. 4). The most popular topics in the *Climate Change* field concern:

- Alternative and nuclear energy;
- Carbon footprint of human activity;
- Solutions to the problem;
- Hydrogen and electric vehicles;
- General notions of global warming and its impact;
- Overconsumption and the need for degrowth.

The field of *Health* (Medicine) shows strong connections to the current COVID-19 pandemic. We identified the following topics:

- The covid-19 pandemic: social thread, treatment, vaccination;
- Mental health;
- Difference between bacteria and virus;
- Machine learning methods in medicine;
- Impact of Wifi and other waves on human health;
- Explanation of research methods and propagation of health knowledge;
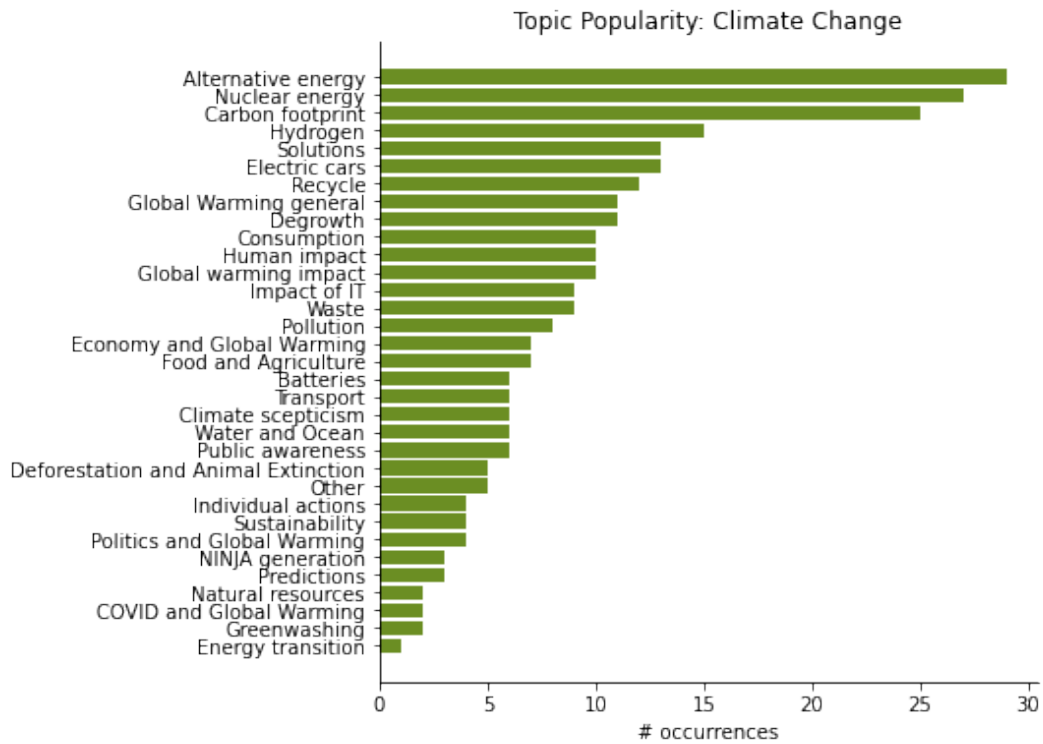- Protection of personal medical details on the Internet.

Figure 4: Topic popularity of *Climate Change* questions

Taking into consideration an impact of the field of Education of a respondent on the topics he / she is interested in, we notice that Humanitarians differ from other groups by their choice of "human factor" and "everyday routine" in the scientific texts popularization and simplification. They wondered *what are the ethical problems of artificial intelligence*, *what are the challenges of "alternative" medicine*, *how to use Excel for business*, etc. They also ask to provide *Comparison of people's attitude to this topic in different countries*, while articulating the problems of the Climate Change, and to keep the traditional education system in school *The importance of a traditional education in schools - I am not a big supporter of the fact that currently everything is becoming digitized :(*, while discussing Health. Respondents, who studied Biology and Natural Sciences, advised to attracts non-experts' attention to precise scientific topics like *Malnutrition*; *Comment funcione un ordinateur et l'internet*[13]; *Utilisation addictive des portables, des ordinateurs ou de l'internet*[14]; *Comment fonctionnent les réseaux sociaux?*[15] *Fonctionnement du système de publications dans les revues scientifiques et médicales et la revue par les pairs ?*[16] Meanwhile, the Information Sciences and Technology specialists offered to simplify key issues of AI and ML for the general public to overcome their fears: *Pourquoi l'IA est uniquement un*

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[13](French) How do a computer and the Internet operate?

[14](French) Addictive use of mobile phones, computers and the Internet

[15](French) How do social network work?

[16](French) The process of publishing in scientific and medical journals, pair reviewing process

terme marketing[17]; *Les réseaux neuronales*[18]; *Les capacités de l'IA en règle générale : qu'est-ce que ça permet de faire aujourd'hui et où en est-on (Google Maps, Siri, classification de données, traitement d'images médicales, voiture autonome, etc.) et quel est l'objectif pour la suite (passer d'AlphaGo à de la réelle stratégie militaire, création de texte/musique à partir de rien, génération de contenu automatique par GAN, et par la suite les AGI et ASI)*[19].

Thus, professional knowledge affects the choice of the topics and the image of an average recipient of simplified scientific texts our respondents have in their minds.

5. Conclusions and Discussions

The study of the people's queries on the forums and topics of the scientific journalists' articles reveals the gap between the actual interest of the wide readership and the expectations of the journalists. Science-related *Yahoo!* questions in many cases were about asking for an explanation of everyday phenomena and human body functioning. Although answering these questions requires knowledge in natural science, it would be difficult to find answers in scientific publications, as in many cases answering these questions presupposes inference from common and scientific knowledge. Nevertheless, it is obvious that *Yahoo! answers* users do not expect any serious scientific clarification. The *Yahoo! answers* service shows weak association with scientific topics. The results of the queries analysis of *Yahoo! answers* are useful for the SimpleText project since they reveal the interests and fears of the users that we can associate with relevant information in the scientific publication (as the contagion of the coronavirus, see Table 2).

The topic of the queries on *ELI5* and *ScienceX* are very similar, therefore the *ELI5* users can find useful information in this network. Nonetheless, the forum users are interested in short and precise answers, they are not motivated to enhance their general knowledge at the moment. The users of *ScienceX* attend the network; however, it is impossible to find precise answers on a particular question in the publications. Users of *ISTEX* expect to obtain objective information about research and technology; their queries are more similar to the *ScienceX* network titles than to the queries on *ELI5* (see Table 2).

Thus, we can discuss the answer *RQ1: What scientific topics attract attention of the general public?* People would like to learn about Biology and modern technologies; however, they keep in mind precise questions that are useful in their current everyday activity. Scientific text simplification is able to provide information about the current state of a particular scientific issue; meanwhile, readers of simplified texts have to develop a link between the scientific knowledge and their life experience. We consider that a simplified scientific text needs to contain references to the people's everyday experience. The references can bridge the science and routine, on the one hand, and improve the image of science in the reader's minds, on the other hand.

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[17](French) Why AI is only a marketing term?

[18](French) Newral networks

[19](French) General capabilities of AI: what does it allow to do nowadays and what is it its current state (Google Maps, Siri, data classification, medical image processing, autonomous vehicle, etc.), and what are the perspectives (passing from AlphaGo to real military strategies, text/music generation from scratch, automatic content generation using GAN, and next, AGI and ASI)

Our *RQ2: Do the attractive topics match the categories that are described in popularizers' articles?* concerns similarity between the topics of users' queries on the forums and the scientific issues discussed in the articles on *ScienceX*. Categories of the scientific publication conform to the most frequent queries on the ELI5 forum. Users of the forum consider Biology and Technology useful for explaining and looking for solutions in their everyday activity. Nonetheless, the users do not use scientific terminology in their queries and are not supposed to welcome the terminology in the answers. Correspondence of the categories does not mean that the popularizers' articles match the communicative expectation of the forum users.

The survey results show disagreement between our respondents' understanding of the hot scientific issues and popular issues of the popularizers' articles in *ScienceX* network. Comparing the topics popularity (see charts in Figures 3, 4) and frequent terms in *ScienceX* (see Figure 2), we consider the network more concentrated in the biological topics. The specialists, who participated in the survey, showed profound comprehension of ordinary reader's needs in scientific information. Professional knowledge of a particular subject affects the choice of the topics and the image of an average recipient of simplified scientific texts our respondents have in their minds. Those, who studied Humanities and Social Sciences, had better understanding of *ELI5* users; their suggestions were closer to the forum queries. The specialists in Biology and Natural Sciences offered particular topics that showed their concern to provide the readership of simplified scientific texts with some information on how scientists work out research on hot issues. The professionals in Information Science and Technology revealed the viewpoint of researchers who are aware of the people's bias about technologies and are ready to educate them.

Answering our *RQ3 (What scientific topics potential researchers consider useful to popularize?)*, we emphasize the approach, which the researchers revealed in the survey. The potential researchers offered to take into account ordinary reader's needs to associate their particular problems with the opportunities that science provides them to solve the problems.

Although the results were not directly applicable for the SimpleText@CLEF workshop, we obtained some valuable insights. Queries belong mainly to one of the following categories: (1) *"how to … ?"* (e.g. get rid of a virus, hack a Facebook account) and (2) *"what is the best … ?"* (e.g. computer, programming language, software). Thus, people outside a specific scientific field are mainly interested in how to solve their problems. This is also true for the professional computer science forums like *StackOverflow*[20], where users ask *"how to … ?"* questions. These insights are especially valuable for content selection. For people, the most important information is the application of an object (which problem can be solved? how to use this information/object?).

The results of the survey also drive our attention to reliability of scientific resources from the ordinary reader's viewpoint. The forums and social media provide fast and easy access to scientific information. Even news stories judged to be true according to fact-checkers spread more slowly than fake news and reach fewer people [7]. Sixty percent of Americans get their information via social media [8]. During the COVID-19 pandemic, fake news might influence the public's adoption of public health responses and policies, rumours in social media about economic instability due to the current pandemic affect the traders' behaviour on the global markets, students and lecturers share their disappointment about online seminars that confuses

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[20]https://stackoverflow.com/

those who planned to enhance their education in university. The stories the individuals find credible can determine their response to the pandemic or another disaster. which can give rise to more COVID-19 cases or provoke exaggerated actions like arson of 5G cell phone towers in the UK blamed for the spreading of coronavirus [9]. On the one hand, according to Sanderson et al. [9], it seems difficult for ordinary people to identify false or misleading news. Only 30% of participants of their study were able to spot a fake news of coronavirus origin. On the other hand, even those, who are able to recognize disinformation, are often in a hurry to share news before critically considering information, thus contributing to the propagation of fake news (e.g. [10]). Sanderson et al. [9] showed that people with higher levels of education better identify disinformation but still they are correct in about 40% of cases only. Therefore, well educated people are also in danger of making wrong decisions based on disinformation. That is why making scientific publications easier to access and to comprehend becomes a challenging task nowadays.

Acknowledgments

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