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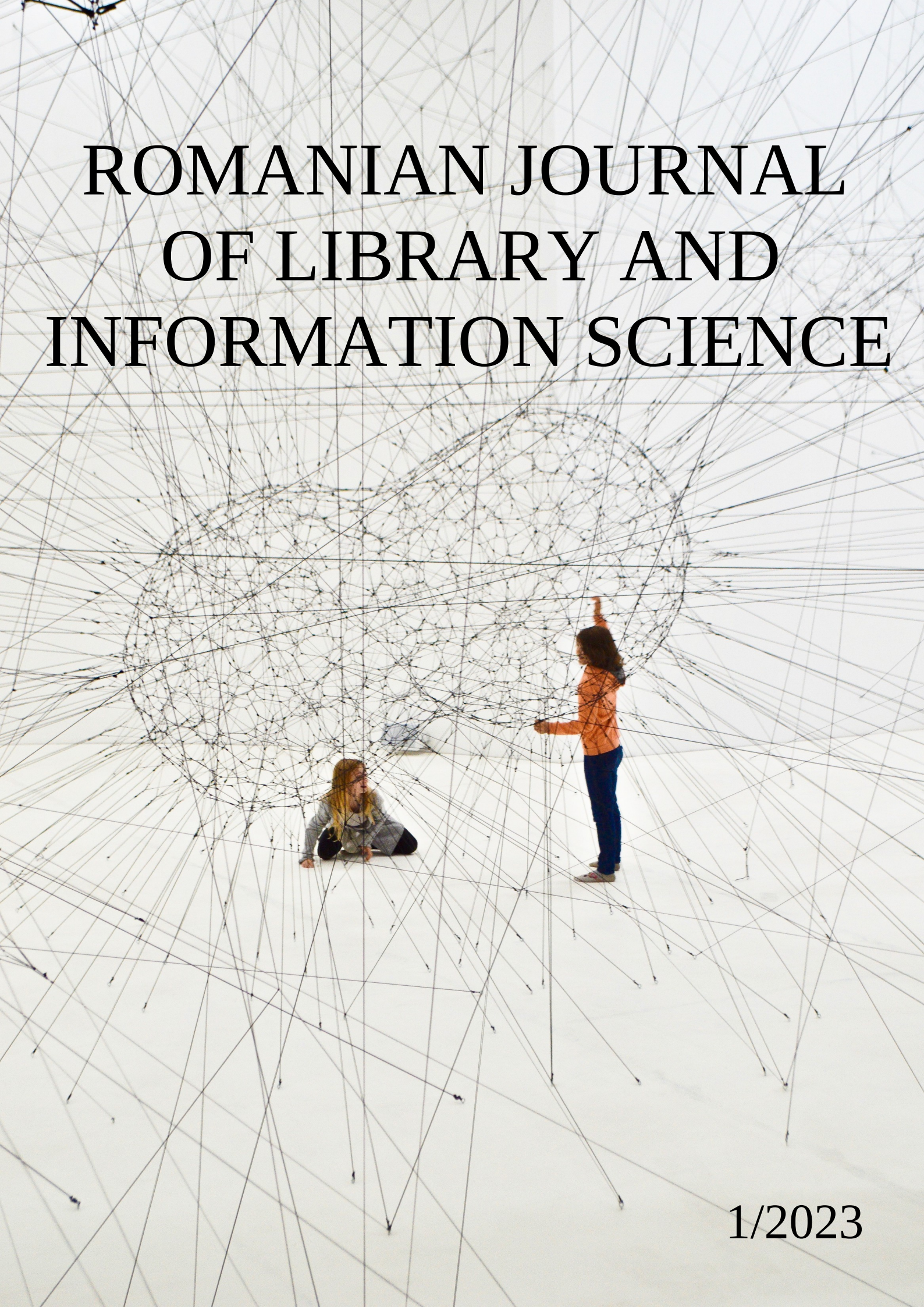

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Students' Information Seeking Behavior and Information Needs

A Case Study of "Babeș-Bolyai"University

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Abstract:
All around the world, universities and university libraries have faced the decline in the importance as a physical entity. This decline has multiple causes, such as the change of users' expectations and needs, the universities switch from exclusively on-site work and teaching to remote or more flexible schedules, the availability of alternative sources of information, the use of new technologies (social networks, mobile technologies), the preference for anytime and remote access from personal devices, the demand for greater compatibility and interoperability of systems, and the transformation of library user from consumer into content creator. Thus, this research aims to study the information-seeking behavior of college students in the context of traditional and electronic resources). Urquhart and Rowley's model of information-seeking behavior will be applied along with Wilson's model, to identify the factors that influence information-seeking behavior: the design of information resources, the educational infrastructure, the organizational culture, the availability and access constraints, the information culture, the search strategy, the support and training, the pedagogy, the behavior of teachers regarding information, and the study discipline and curriculum. Nonetheless, the article will explore information literacy skills and the barriers to accessing and using them: cultural aspects related to teaching and learning styles, language proficiency and digital culture.

Keywords*: Information-seeking behavior, Academic libraries, Information literacy, Literacy*

1. Introduction

In the academic environment, electronic resources have become the primary medium in which information seeking behavior occurs. Consequently, the relationship between the information seeker and digital resources must be constantly evolving (Wilson, 2006). With the beginning of the third millennium, research in the academic environment began to be increasingly based on technology. Faculty members, researchers, and students have access to dynamic and interactive digital facilities that constantly provide instant connectivity via university computer networks. They have the possibility to choose from several information delivery systems and from a wide range of sources and channels of information. Information can now be obtained anytime and anywhere. However, easy access does not imply that the information retrieved will be both relevant and

reliable for users. Given the variety of information resources and the technological progress, it is important for libraries to understand how students and academics navigate through information environment, in order to effectively design the systems and services they provide to users (Wilson, 2008).

The aim of this research is to examine the information seeking behavior of students at Babeş-Bolyai University, and to identify the factors that influence their information seeking behavior. The goals refer to:

1. Identifying the users (students) information needs, necessary to fulfill their academic goals.

2. Exploring the level of awareness and knowledge of available information sources, especially the online ones.

3. Identifying students' perceptions of their skills related to information literacy.

4. Exploring users' awareness of library resources and their ability to use them in order to accomplish their tasks.
5. Exploring the factors (both hindering and facilitating) that influence how users seek information to meet their research and learning needs.
6. Identifying the influence that teachers and librarians have on students' information-seeking behavior.
7. To make recommendations regarding the diversification of library services to meet the users' information needs.

Research Questions:

1. What are the characteristics of the information-seeking behavior of Babeş-Bolyai University students?
2. To what extent are they aware of the information sources available online for their areas of interest?
4. What are the most important factors influencing information-seeking behavior (role-driven, psychological, demographic, environmental).
5. What impact do teachers have on students' information-seeking behavior?
6. How can the role of libraries and librarians be increased to meet the users' information needs?

2. Definitions

Information-seeking behavior: Case (2016) defines information-seeking behavior as a persons' "conscious effort" to obtain information in response to a need or lack of expertise. For Wilson (1999) information-seeking behavior is an "activity" pursued by a person in order to search, identify, use and communicate information that he considers relevant in a certain context.

Information literacy: CILIP (the Chartered Institute of Library and Information Professionals) defines information literacy as "knowing when and why you need information, where to find it and how to evaluate it, how to use it and communicate it in an ethical manner" (Law, 2008). Due to the development of technology, information literacy has become equally important as computer literacy, critical thinking, and library skills (Schroth, 2022). In this paper,

information literacy is defined as: “the set of skills needed by individuals to recognize when information is needed and to have the ability to find, evaluate and effectively use the desired information” (Association of College and Research Libraries ACRL, 2000). ACRL has established 5 standards that determine the level of students’ information literacy. According to these standards, students can (a) determine the nature and amount of information they need, (b) can access information effectively and efficiently, (c) can critically evaluate sources and information they find, (d) can understand and use information for the achievement of a specific task, and (e) use information respecting the legal limits and ethical standards of academic research (Repanovici, 2012).

Information need: As Case (2016) stated, information is needed in order to reduce uncertainty. He defined information need as the awareness of a certain person that he has insufficient knowledge about a certain subject to be able to achieve his goal.

Information use: in this paper information use is consistent with the definition of Hughes (2005) who claims that it is a complex experience that involves context, needs, actions (information seeking behaviors), responses, influences (cognitive, affective, cultural and linguistic) and results (understanding, knowledge development).

3. The conceptual framework

In order to achieve the goals and objectives of this research, it had been proposed Wilson’s (1999) information-seeking behavior theoretical model. According to Wilson, information-seeking behavior occurs as a consequence of a need perceived by an individual, and in order to satisfy that need, he uses formal or informal sources of information, which result in success or failure in finding relevant information. If he is satisfied, the individual uses or forwards the information and if he is not satisfied, he resumes the search process. Wilson's model is based on two main statements: first, that the need for information is not a primary need, but a secondary need, which derives from basic needs (physiological, cognitive or affective); second, in the effort to discover information to satisfy a need, the seeker will encounter barriers of various kinds. Wilson argues that the individual himself, the roles he fulfills in his personal life or at work, and the environment in which he operates are the contexts of emergence and manifestation of these needs. The barriers to information seeking will appear within the same set of contexts.

The theoretical model would serve as a framework for building research tools, formulating hypotheses, collecting data, analyzing results and formulating conclusions. This model of information behavior would also guide the study, based on the set of mediating variables identified by Wilson as affecting the information-seeking process: psychological, demographic, role-related, environmental, and resources characteristics. Since Wilson's model is a general one and the present research requires the identification of a specific set of factors that would allow hypotheses to be formulated, a set of factors identified by Urquhart and Rowley in a study conducted in Great Britain, would be integrated within Wilson's model. Urquhart and Rowley (2007) identified two categories of factors, macro factors and micro factors, with direct (micro) and indirect (macro) influence on information seeking behavior. The associations between these factors can be tested, and this fact is consistent with the objectives of identifying the key factors influencing information-seeking behavior of this research. In addition, Urquhart and Rowley's study established a set of variables analyzing electronic information-seeking behavior in academic environment. These factors are: design of information resources, educational infrastructure, leadership and organizational culture, availability and constraints related to access, information literacy, search

strategy, support and training, pedagogy, behavior of teaching staff regarding information, discipline and curriculum.

This research focuses on exploring students' patterns of information-seeking behavior, and identifying factors that influence the information-seeking process. These patterns include:

• The place where the search is carried out: at home, in the library or in an office;
• Usage of library resources, electronic journals, search engines, and personal contacts to find the necessary information;
• Problems related to access or computer usage while conducting the search;
• Asking for help if needed.

4. Methodology

Based on the conceptual framework and research questions, hypotheses had been formulated in order to test whether certain factors influence the information-seeking behavior. These hypotheses are as follows:

1. There is a significant correlation between students' information-seeking behavior patterns and (a) reading habits; (b) confidence in one's own information literacy skills and (c) level of knowledge of a foreign language.
2. There is a significant correlation between students' information-seeking behavior patterns and (a) gender; (b) environment of residence and (c) age.
3. There is a significant correlation between students' information-seeking behavior patterns and (a) college; (b) level of study and (c) frequency (full time or distance learning).
4. There is a significant correlation between students' information-seeking behavior patterns and (a) teachers' demands; (b) teaching style.

The hypotheses had been tested using a survey which had been constructed by adapting several scales: a scale measuring information literacy, validated in the study of Kurbanoglu, Akkoyunlu and Umay (2006) and another designed by Baker (1997) that measures students' use of library services and resources.

Method

The study was conducted using a survey. The sample (N=54), contained 24.1% men and 74.1 % women, with ages varying from 18-25 (%) to 26-35 (%) and over 36 (%). Regarding the college where they are enrolled, 22.2% attend a college in the field of humanities, 64.8% in the field of social sciences, and 13% either did not answer the question or indicated the Babeş-Bolyai University instead of their college. The data collection was done between May-June 2022.

Instrument

An online questionnaire was applied. Is has been constructed by adapting several scales: a scale measuring information literacy, validated in the study of Kurbanoglu, Akkoyunlu and Umay (2006) and another designed by Baker (1997) that measures students' use of library services and resources.

The questionnaire contained 5 parts plus the introductions, as explained below.

Introduction

The introduction of the survey is a paragraph explaining the purpose of the research, ensuring the confidentiality of the collected data and providing the contact details of the researcher.

Part I: Information seeking

This section aims to obtain information related to the use of information sources in particular situations. The critical incident must be an assignment related to writing a seminar paper, a scientific article, a thesis or dissertation, etc.

Part II: Information literacy

This section contains a series of questions that examine the respondents' levels of confidence in their information literacy skills. The questions in this section are presented as statements to be answered using a five-point Likert scale. The statements cover the following aspects: information need, search strategy, locating and accessing resources, evaluating the relevance of information, interpreting, synthesizing and using information, communicating information, and evaluating resources.

Part III. Teaching method

This section is intended to investigate the role of teachers in influencing students' information-seeking behavior, and the teaching styles adopted within different disciplines.

Part IV. Perception regarding the role of the library

Using a 5-point Likert scale, this section intends to measure students' attitudes toward the use of the library, and their perception regarding library's role in the academic community.

Part V: Demographics

This section of the survey contains closed questions regarding gender, age, residence, college, level of study (bachelor or master) and frequency (full-time or distance learning). Respondents are also asked to rate their level of proficiency in a foreign language.

5. Results

75,9% of the respondents rated their level of proficiency in a foreign language as *Independent* (B2) or *Proficient User* (C1, C2) and only 9,3% as *Basic User* (A1/A2). Regarding the confidence in their information literacy skills, 98% claim that they like to do research and that they do so for projects or seminar assignments (90.8%), 79.6% know what need to be done to get the information they need, 79.6% know how to narrow their search by subject, language and publication date, and 66.7% know how to use Boolean operators. Likewise, 75.9% know how to determine whether a source is reliable, 87% know how to select the most relevant information for their field of interest, and 75.9% know how to compile bibliographic references for all types of documents (books, book chapters, articles, web pages, etc.). 66.7% of respondents claim that they ask teachers for help when researching for an assignment or project, 68.5% use the Google search engine, 42.6% ask their friends or colleagues and only 22.2% ask a librarian for help. When asked to express their preference for the format of the documents they use as a source of information, 72.2% of respondents claim that they prefer documents in electronic format because they can use keywords in the research process (63%), they can search inside documents (64.8%), and 35.8% appreciate the fact that electronic documents can be inserted into automatic translation software. Also, 90.8% prefer books over journals (38.9%).

Regarding the library usage, 51.9% of the respondents claim that they have never been to the Central Library or the faculty library (68.5%), while 14.8% visited the Central Library and 9.3% the faculty library, at least once a week. Regarding the role of the library within the academic community, 46.3% of the interviewed believe that the library helps to stimulate creativity among members of the academic community, while 26% neither agree nor disagree with this statement; 60% believed that the library helps promote a sense of community between members of different groups, 54% believe that the library creates educational opportunities for all audiences, while 54% agree that the library provides a neutral space that serves as a place for meeting and debate on various topics and a hangout place for the academic community (48.1%).

When asked *what the library should do to better serve its patrons*, 65% believe that it should have more comfortable spaces for reading, research and relaxation, 62% want more reading rooms, IT areas, work spaces for small groups; 85% want training courses for the use of new technologies, digital skills or academic writing (46.3%) and 39% believe that the library should borrow technology: laptops, tablets, VR headsets, studios portable photo. 9% of respondents suggested purchasing more copies of the most requested publications, making the web page more public-friendly and the library opening hours should be extended after 8 p.m. Also, for the library to promote its services as well as possible, the respondents suggested organizing events to attract students to the library, workshops, tutorials, the promotion of services on social media and through teaching staff, and the improvement of the attitude of some librarians.

5.1. Hypothesis testing

Regarding hypothesis one, that there is a significant correlation between students' information-seeking behavior patterns and (a) reading habits, (b) confidence in their information literacy skills, and (c) level of proficiency of a foreign language, the data collected revealed that there was no significant correlation between the location of the search, the level of proficiency of foreign languages or the reading habits of the students. However, there is a significant positive correlation between where the search is done and confidence in certain information literacy skills. This means that students who have a higher level of confidence in their information literacy skills seek information from the library or IT lab. Confidence in one's own information literacy skills is also correlated with the use of diverse information sources, which could suggest that students who are more confident in their information literacy skills use more different information sources.

Tab.1 Correlation between the location of the search and information literacy

	In the library	In the IT lab
I like to do research	,422**	0,218
I usually do research for projects or seminar assignments	,330*	0,093
I know how to narrow searches by subject, language, and date	0,173	,280*
I know how to use keywords and boolean operators	0,167	,295*
I like to use printed information sources	,415**	,284*
I know how to locate documents in the library using the online catalog	,423**	0,225
I know how to desig a research project	,407**	0,251
I know how to reference different types of documents	,291*	0,237

*p<0.05; **p<0.01

Confidence in one's own information literacy skills is also correlated with the use of diverse information sources, which could suggest that students who are more confident in their information literacy skills use more different information sources.

Tab. 2 Correlation between information literacy and the use of information sources

	Search	Electroni	Databases	Online	Piracy

	engines	c journals		catalogs	websites
I like to do research	0,073	,536**	0,174	0,267	-0,045
I usually do research for projects or seminar assignments	0,137	,323*	0,206	0,244	-0,074
I know what to do to get the information I need	-0,025	0,207	,313*	,278*	0,058
I know how to narrow searches by subject, language, and date	0,131	,299*	0,239	0,156	0,266
I like to use different sources of information	-0,036	0,151	,277*	,411**	-,303*
I know how to locate documents in the library using the online catalog	-0,052	-0,066	0,201	,541**	-0,191
I know how to determine if a source of information is reliable	0,041	0,198	0,221	,306*	0,153
I know how to select the most relevant information for my field of interest	0,036	,339*	0,177	,324*	0,089
I know how to desig a research project	-0,037	0,101	0,209	,318*	0,087

*p<0.05; **p<0.01

Quite surprising is the correlation between confidence in information literacy skills and asking a librarian for help. This could indicate either that less experienced students feel anxious about librarians, or that students with more developed information literacy skills have acquired these skills from librarians, which is why they seek their help when they need guidance. Whereas, few data were collected, one can only speculate on this topic. The data collected does not reveal any correlation, however, between the psychological characteristics of the respondents and problems regarding access or computer usage while researching.

Tab. 3 Correlation between asking for help and information literacy

	Librarian	Friend	Wikipedia	Google
I like to do research	,328*	0,097	0,056	0,232
I like to use printed information sources	,608**	-0,12	-0,112	-0,038
I know how to locate documents in the library using the online catalog	,358**	-0,105	-0,081	-0,065
I know how to desig a research project	,332*	0,047	-0,06	-0,007

*p<0.05; **p<0.01

Hypothesis two, which claims that there is a significant correlation between students' information-seeking behavior patterns and demographic characteristics (gender, residence and age) did not find significant correlations, except for where the search took place and gender or residence of the person in question. Thus, the data show that women seek more information from home, but this may be the result of the disproportionate representation of gender in the sample (74.1%

women). As for residence, the data show that those from urban area do their research more often in the library than those from rural area. One explanation could be that library usage is a skill they have practiced since high school. We also found correlations between student age and the resources they use. Data indicates that students aged 18-25 are more likely to use e-journals and pirate sites, while students aged 26-35 and over 35 use the library's online catalog.

Tab. 4 Correlation between age and the use of information sources

	Search engines	Electronic journals	Databases	Online catalogs	Piracy websites
Age	-0,095	-0,255	-0,11	,382**	-,348**

*p<0.05; **p<0.01

The third hypothesis has not been validated. There is no significant correlation between students' information-seeking behavior patterns and role-related variables (faculty, level of study, and frequency).

Regarding hypothesis four, that there is a significant correlation between students' information-seeking behavior patterns and environmental factors (teacher demands and teaching style), data show that students who rate the teaching style of the college they attend as being based on lectures or a combination of lectures and tutorials are prone to search for information in the library space or the IT laboratory and use the library's online catalog. There is no correlation between problems of access or computer usage, and teaching style or teacher demands.

Tab. 5 Correlation between teachers' demands and the location for information search

	The teacher guided me on how to use information sources	The professor laid the foundation for my research activity	The teacher provided me with/recommended articles and scientific research	The teacher gave us assignments or projects that require the use resources available in the library	The teacher guided me in doing literature reseach
Library	0,235	,292*	0,173	,387**	0,23
IT lab	0,09	0,213	,328*	0,263	,329*
Home	-0,011	0,053	0,237	-0,011	0,223
Other	-0,075	-,331*	-0,142	0,042	-0,087

*p<0.05; **p<0.01

Teaching method or teaching style refer to the emphasis on problem-based learning or information-based learning. The lecture-based teaching style and the high demands of the teaching staff also correlate with asking a librarian for help if needed during information searching process.

Tab. 6 Correlation between asking for help and teaching style

Who do you ask for help when reserching for a project or assignment	Combination of lectures and tutorials	Based on critical thinking	Based on individual work	Bazed on team work	Based on experiments	Based on lectures
Teacher	-0,029	0,042	0,072	0,205	0,25	,281*
Librarian	,320*	0,236	0,206	0,14	0,206	,508**
Friends	0,015	0,066	-,311*	0,163	-0,063	-0,002

*p<0.05; **p<0.01

Teachers' demands establish expectations regarding the search for information and are related to the area of study and how knowledge and skill development are structured within the learning experience. As data show, those who consider that the demands of teaching staff are higher in terms of the elaboration of scientific papers, tend to ask a librarian for help.

Tab. 7 Correlation between asking for help and teacher demands

	Librarian	Friends	Wikipedia	Google
The teacher guided me on how to use information sources	0,248	0,049	-0,103	-0,182
The professor laid the foundation for my research activity	0,242	0,124	-0,051	-0,096
The teacher provided me with/recommended articles and scientific research	,326*	0,258	0,175	0,09
The teacher gave us assignments or projects that require the use resources available in the library	,386**	0,016	-0,064	0,089
The teacher guided me in doing literature reseach	,341*	0,195	-0,108	0,106

*p<0.05; **p<0.01

6. Conclusions and furthere research

This research is consistent with studies regarding information need and information-seeking behavior of university students (Chlomoudis, 2022; Dahlqvist, 2021; Haider, 2021; Baba, 2019) and with studies investigating the role of library in student academic success (Mayer, 2020). There are several studies conducted in Romania which investigate patrons' satisfaction with library services (Olariu, 2010; Landoy and Repanovici, 2019; Nealcoș and Chevul, 2016).

The aim of this research is to examine the information seeking behavior of Babeş-Bolyai University students and to identify, in particular, the factors influencing information seeking behavior. The present research is ongoing, which is why it is based on limited data collected from a very small number of subjects compared to the total student population of Babeș-Bolyai University (48,520 students according to the Rector's Report on the State of the University Babeș-Bolyai at the beginning of the academic year 2021-2022). For this reason, only a few conclusions can be drawn as to what the library should do to improve its relationship with students and better respond to their information needs. First of all, The Central University Library needs a wide campaign to promote its services, especially on the social media used by students (Facebook, Instagram and Tik-Tok), because half of the respondents who took part in this study have never visited the Central University Library or the faculty library, although 63% of them are graduate students. Also, a much better collaboration between teachers and librarians is needed, with the aim of improving students' information literacy skills and increasing their autonomy in the information search process.

As previously argued, this research aims to investigate the relationship between a number of variables and students' information-seeking behavior. Cultural aspects related to teaching and learning styles, language proficiency, and digital culture are some of the factors that may influence information-seeking behavior. Thus, it is preferable for them to be analyzed in specific contexts. In this sense, it is necessary to collect data through the survey from as many students as possible, from all levels of study (bachelor, master, doctorate) and from all 21 faculties of the Babeș-Bolyai University. It is also needed to apply semi-structured interviews to teaching staff of Babeș-Bolyai University and to academic librarians, who have been carrying out public relations activities for at least 10 years. These semi-structured interviews will allow for the collection of detailed information about teachers' and librarians' perceptions on students' information skills when carrying out assignments or research projects for academic activities. They could also reveal academic librarians' and teaching staff expectations, suggestions and recommendations on how to improve students' information literacy. Focus group interviews with students could be another way of obtaining detailed information about how students search for information and the problems they face when using electronic resources.

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Does ChatGPT influence research fields in the same way? A Scientometric analyses

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Abstract:
Artificial intelligence has invaded our academic space since ChatGPT left. Students were interested in seeing the potential of many debates. The authors conducted a scientometric research to identify the areas in which the researchers published articles on Chat GPT. The Clarivate Analytics database was used, search by ChatGPT keyword. The 57 results were analysed using VOS Viewer. There are many PRO opinions on the use of Chat GPT in education, medicine, mathematics and other sciences.

Keywords: *ChatGPT, Artificial Intelligence (AI), Scientometrics, VOSViewer*

1. Introduction

Scientometry is an important tool for understanding certain aspects of research results. Bibliometry is the statistical analysis of books, journals, scientific articles and authors. The analysis of the frequency of words, the analysis of citations or the number of articles of certain authors were the basic elements for such statistical studies. In the modern period bibliometry was transformed from a simple study of bibliographic statistics into a distinct field of study

There are several advantages in implementing bibliometric analysis that makes it suitable for the evaluation of research: provide an evaluation of scientific production in a given research area over a period of time, using indicators to evaluate research performance.

VOSviewer is a free and open sourse software developed by University of Leiden, Netherlands. It is used for scientometrics analyses and for visualization research data.

2. Methodology

ChatGPT is the most popular chatbot for many reasons. Firt of all, it is a large linguistic model, which means that it has been trained on a massive set of text and code data. This allows it to understand and generate text with a greater accuracy and fluency than other chatbots.

Second, Chat GPT is accessible to the general public. It is freely available to anyone to use through the OpenAI website. This has made ChatGPT easier to know an use by poeple around the world.

Third, ChatGPT is regularly updated, improved response quality, can be fine-tuning and customised for specific use cases and domains.

Here are some of the features that contribute to ChatGPT's popularity:

- Natural language understanding, it has been trained on a massive amount of diverse text data, this helps to generate human-like responses.

- It has contextual understanding, is designed to maintain context through a conversation, it can remember and refer back to previous messages, allowing for more coherent and relevant responses.

- It can be used for a variety of tasks, including providing information, translating languages and generating creative content.

By accessing Clarivate Analytics, we have identified 57 results from the following fields: Internal General Medicine -9, Engineering Biomedical-7, Computer Science Artificial Intelligence -5, Education Educational Research -5, Education Science Discipline -4. (Fig.1).

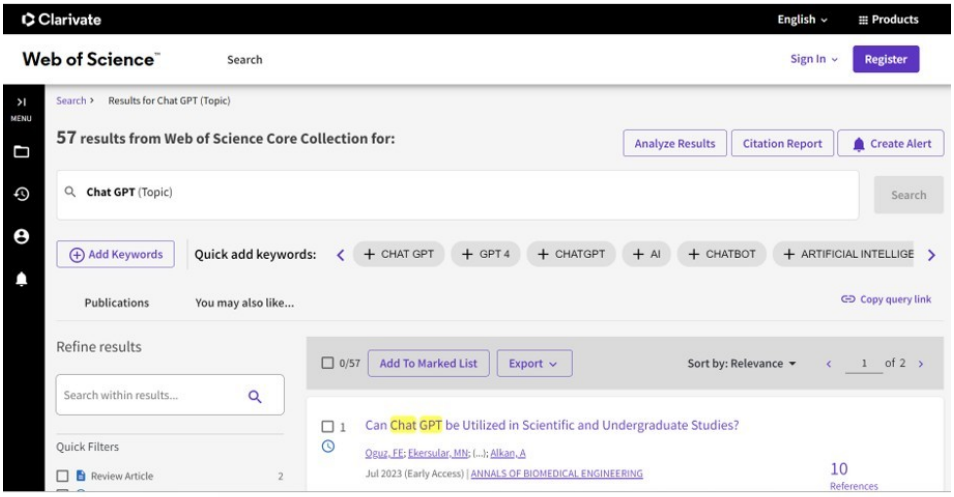

Fig. 1: Screenshot Clarivate Analytics searching keyword ChatGPT

The most productive authors who have so far managed to publish 2 works are Llyod, Nathan, Biswas, Som, Montagne, William, Yu, Hao.

3. Data analysis using VOSViewer

The most productive countries are USA, Spain, Italy, Germany, India. (Fig.2)

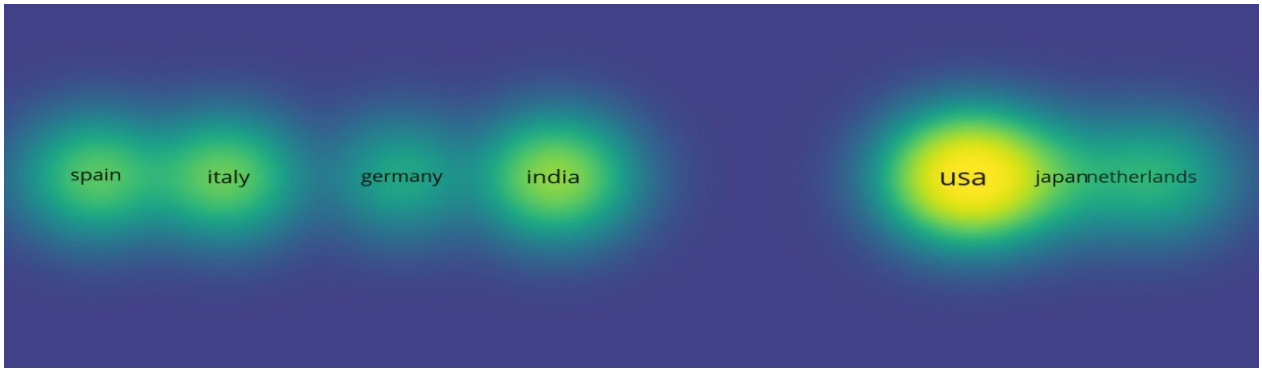

Fig. 2: VosViewer, Productive Countries Density Map

By analysing the co-occurency on the keywords used by the authors, 299 keywords represented in the map in the fig were obtained. 3

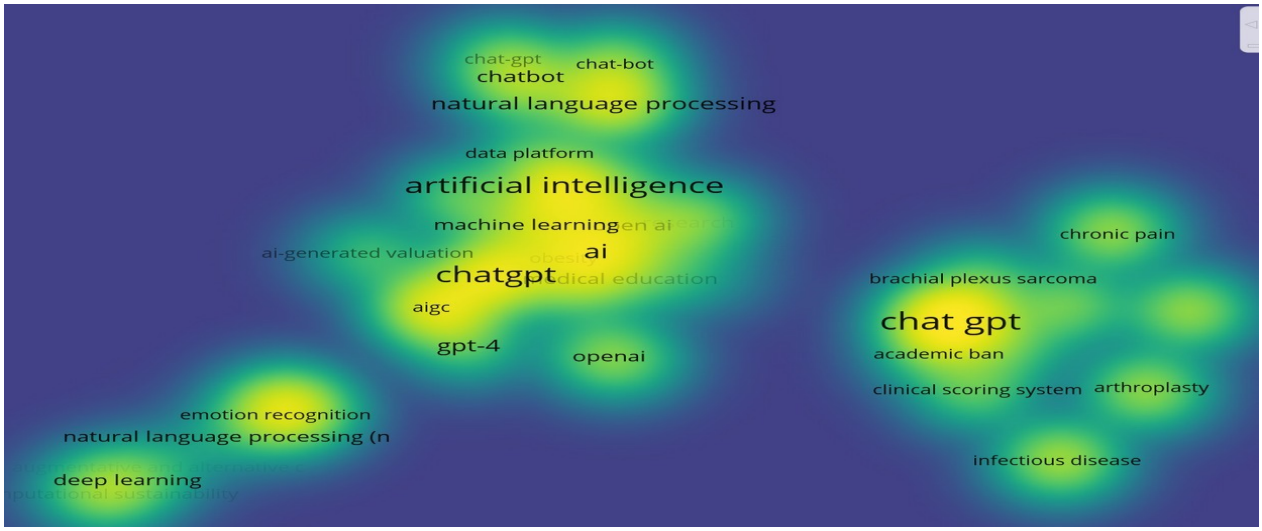

Fig. 3 VOSViewer Keyword Density Map

4. Conclusions

Artificial intelligence is used in the documentation process through ChatGPT. It opened up new approaches to its use in higher education.

By analysing the articles published in Clarivate Analytics, we came to the following conclusions:

A systematic review of AI research in higher education, published in 2023 by Cromton, identified gaps in the literature to be used as a spring ramp for future researchers, including new tools such as Chat GPT. (Cromton, 2023)

The application of AI in higher education has attracted significant interest in recent years, in particular due to the development of information and communication technologies. AI has become an essential tool in all academic fields, including language, engineering, mathematics and medical education. (Alajmi et al., 2020).

AI has become a key tool in all academic fields, including language education (Liang et al., 2021), engineering education (Shukla et al., 2019), mathematical education (Hwang & Tu, 2021), and medical education (Winkler-Schwartz et al., 2019).

Researchers have identified a number of potential benefits of using AI in higher education, including:

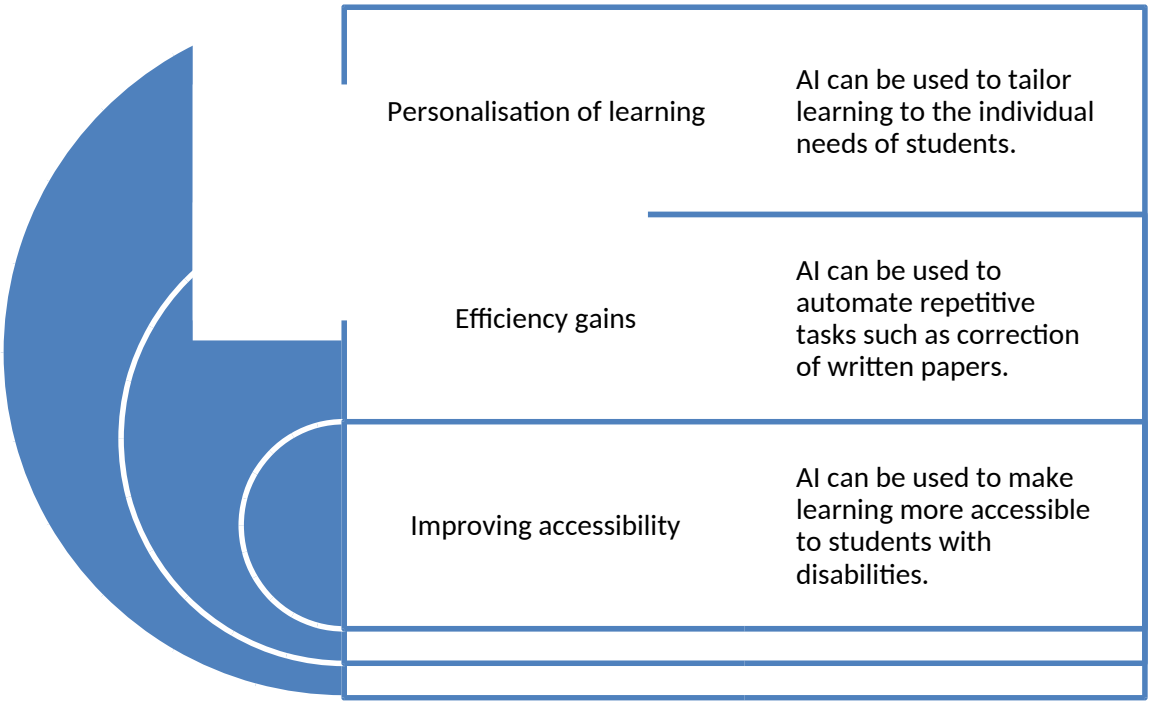

Fig.4: Benefits of using AI

AI can analyze large amounts of data to identify trends in student performance, helping educators to improve teaching methods and curriculum design.

But, AI in higher education sector should be accompanied by careful consideration of ethical implications, issues such data privacy, algorithm bias, and responsible and ethical use of AI technology, to ensure its positive impact of education.

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Research and cultural metadata exposed using APIs: steps on the interoperability road

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Abstract
The wealth of data available to the researchers and to the curious citizen seems limitless today. For this reason tools able to retrieve and put together pieces of useful data are in growing need. This study is looking into Application Programming Interfaces as means to establish an ecosystem fostering data interoperability for persons and machines. The research and culture landscape is in a continuous need for accessing to data and metadata. For this reason, a set of the most representative service providers were investigated through the filter of data accessibility, and how the data provided fit the needs of possibly machine-assisted tools. The providers are well established actors in the scholarly communication arena with a host of some from the culture heritage field. A supplementary set of trusted repositories which are recipients of CoreTrustSeal (CTS) were investigated in searching for interoperability extensions via APIs.

Keywords*: application programming interfaces, api, research metadata, data sets, interoperability, vocabulary namespaces*

1. Introduction

Existing APIs are an integral part of the big systems, sophisticated software implementations that are managing research data and metadata obtained out of the current practice. The data are produced by the memory institutions (libraries, archives, museums), and international scientific information resource providers. According to Crossref in 2022 a number over 7.2 million scientific articles were published (Knoth and Zdrahal 2013) setting a contextual figure that ensues a need for different approaches dealing with research outputs. A blog post (Shouten 2023) from the same service mentions 140 million metadata records deposited by the end of March. CORE through The Open University, the biggest Open Access scientific research aggregator reports in 2023 that 275 million papers are available to access and use through their services out of which 140 million full text papers. This deluge of scientific research results needs new approaches with regards to access the wealth of information trapped in the works. Researchers need new ways to access the research outputs, and new ways to find valuable and suitable data and information in the growing heap. To this end, Application Programming Interfaces (APIs) are rising as a way to pinpoint and access the right pieces at the right time.

APIs are not the means to an end when data is the target, but means to access useful metadata without using the interface of a particular system.

In order to investigate the existing APIs, a selection of representative data providers were taken under scrutiny coupled with the dataset of the CoreTrustSeal certified data repositories available at https://amt.coretrustseal.org/certificates. The reason behind this coupling in the analysis is driven by the mandate for long term digital preservation, which in turn guaranties also metadata and data preservation with a continued provision for access. The main concept followed in research data European policies is data management life-cycle, and part of this cycle is accessibility. The study looked into what characteristics of the API and what parts of the metadata representation of the digital objects would be useful in terms of easy access, interoperability, and reusability.

2. Analysis of the APIs

The aim of the analysis is to determine the general common characteristics, the most used serialization formats and protocols, if the endpoints are documented, what range of identifiers are available belonging to what namespaces, and which are the limitations. The APIs were selected from the scientific research / scholarly communication and cultural heritage domains. The living dataset is available for further investigation at Github: https://github.com/kosson/apis-data-source.

To complete a comprehensive picture, a number of fifty two APIs were analysed seeking to determine what a researcher should expect from the endpoints on the following axis:

- access mechanisms (protocols and standards);
- serialization formats;
- metadata schema used;
- common identifiers used for the entities present in the metadata records;
- access and rate limitations;
- Github/Gitlab presence;
- bulk download availability.

The folowing APIs were taken under investigation: American Archive of Public Broadcasting API, arXiv API Access, Springer Nature API portal, Caselaw Access Project bu Harvard Law School, Congress.gov API, CORE API, Crossref REST API, Dataverse, Digital Public Library of America, Europeana API, HathiTrust Digital Library, IEEE Xplore API, Internet Archive Developer Portal, The Lens, JSON/YAML for LoC.gov, Chronicling America, The New York Times Developer Network, OECD data for developers, Open Researcher and Contributor ID, Joint Research Centre Data Catalogue, data.europa.eu - The official portal for European data, Elsevier Research Products APIs, F1000Research, Clarivate Developer Portal, Wiley Online Library, Crossref Unified Resource API, Data.Bibliotheken.nl, BnF API et jeux de données, Open Data at the BnL, German National Library catalogues, Data Catalog of the National Library of Finland, Museums Victoria Collections, Kungliga biblioteket Library Database API, The OpenAIRE APIs, Semantic Scholar Academic Graph API, { NASA APIs }, OpenCitations, re3data.org, Digital Bodleian Search and Data, OpenAlex API, Europe PMC, DOAJ API, Open Library, WorldCat Search API, Exlibris Alma REST APIs, Research Organization Registry, Sherpa APIs, DataCite REST API, bioRxiv API, Altmetric, Unpaywall, FAIRsharing API.

These APIs were thoroughly investigated and in cases where documentation did not provided easy to access samples of data, accounts were created under providers' guidance to obtain access tokens for securing downloads.

The following providers went under testing in order to obtain sample data using the well-known Postman[1]: arXiv, Orcid, Springer Nature, FAIRSharing API, DPLA (Digital Public Library of America), New York Times, and Elsevier.

The investigation carried out looked into the possibilities for Text and Data Mining if that possibility was explicitly mentioned by a provider. A particular attention was given to the diversity of the providers seeking a revealing well balanced mix of practices and records variety. In the end, the structures and metadata of the digital object representation would point out what is is possible to do with today existing instruments, and the existing metadata. Open Data produced by the Public Sector Information generating institutions were excluded. This decision was driven by the vast swats of catalogues already existing which would potentially skew the perspective due to the sizes and already well ahead practice homogenization. In this context, several conclusions of the 2020 report: *Application Programming Interfaces in Governments: why, what and how*(Vaccari *et al.* 2020) states the need to introduce APIs as a component of digitization due to their modularity and high degree of reusability. At the European level, the adoption of APIs should be done in a coordinated way to avoid the negative effects that ad hoc adoption brings to long-term exploitation. One aspect well captured in the report is that APIs allow institutions to avoid the data "siloed" effect.

2.1. Method used

The data was gathered during five months beginning with February of 2023 ending at the beginning of June. A good balance was sought with regards to the institutions involved in this study. Scholarly communication and cultural heritage fields were chosen as data originating form their APIs has the potential to connect and become pieces of exploitation chains/workflows. All APIs were investigated accessing their institutions' sites, reading the help and FAQs pages. For most of the APIs discovered accounts were created looking into the possibilities of accessing data and metadata directly. After accounts were created for the outlets requiring this approach, a collection was created in specialized software Postman aiming to extract sample data for further analysis. The analysis of these samples was done to find the identifiers used in the data and metadata.
The national and international data portals for public sector information were not included in this study because of the sheer size and the scope of those repositories.

[1] https://www.postman.com/

2.2. Access mechanism

The most important aspect sought after by the data savvy researcher is the means to gain access to the data and metadata. As expected, the prevalent means of access of today is through the use of HTTP protocol. And this comes with the following explanation. Into the HTTP request-response cycles we have assimilated all sorts of querying forms. The prevalent model is following a RESTful behaviour.

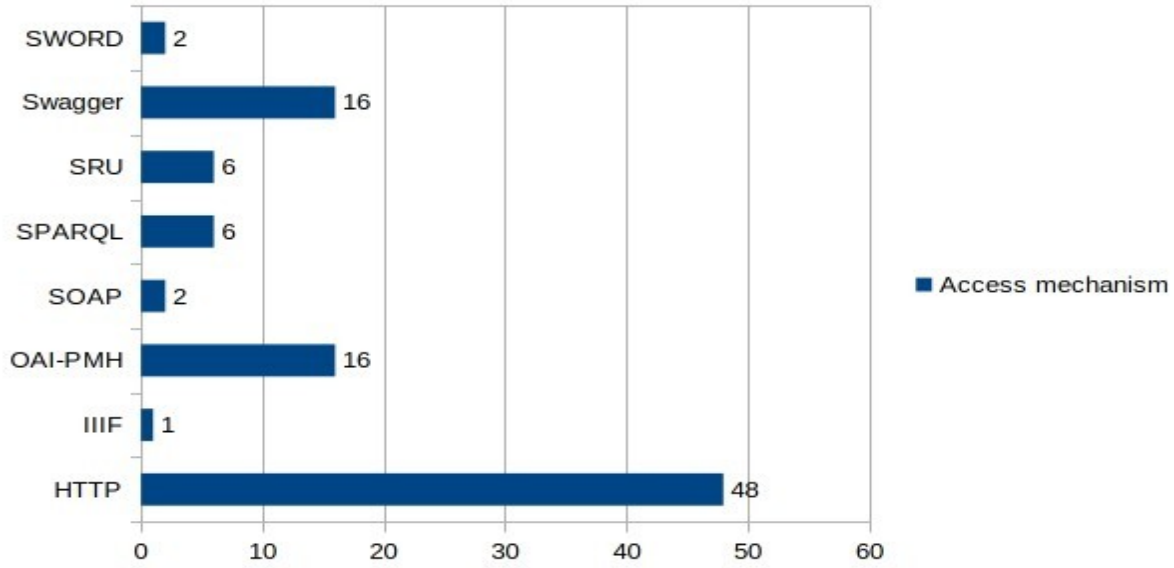

Figure 1: Means of access to data, generically called access mechanism

As seen in the Figure 1, most of the protocols mentioned are using HTTP protocol as subsidiary means of communication, but what is worth mentioning is the diversity of protocols/specifications in use. At times, some of the providers offer multiple means of access to the metadata. Relevant for this variety are mostly cultural heritage institutions like Data Catalog of the National Library of Finland, BnF API et jeux de données or Kungliga biblioteket Library Database API with a notable research outlet: Exlibris Alma REST APIs.

Another aspect pointed out is that the OpenAPI Specification (Swagger) gains traction as an uniform way to document and present the endpoints through which an interested party may access the metadata. The increase in the desire to standardize access is noticeable, as testified by the existing documentation of endpoints using Swagger (https://swagger.io/), that is, adherence to the OpenAPI specification, in fact. This is due to the need to have APIs that behave predictably, benefiting from the best practices of the last twenty years. I chose to introduce also SPARQL (SPARQL Protocol and RDF Query Language)[2], which is also a possible path for querying semantic databases. This option was introduces by the realities of APIs query mechanisms encountered. Some of the providers also expose a SPARQL endpoint in addition to RESTful ones. This adds complexity and is prof of existing curated knowledge graphs, a higher form of data aggregation

[2] https://en.wikipedia.org/wiki/SPARQL

addressing very specialized users. The renown technology analyst Kurt Cagle explained in one of the best articles hosted by Data Science Central(Cagle 2022) what are the powers of the Knowledge Graphs, and how organisations are taking advantage of this technology able to accommodate desired ontologies. There is a potential conclusion here concerning the API relation with the knowledge graphs. Some of the analysed organisation might have their own internal knowledge graphs shaping data according to their own ontologies of their own choosing. The access to external parties is offered through *common APIs representing access to resources that can be styled in specific ways*. In turn this leads to a failed reuse scenario as Mr. Kurt argues that *the interoperability argument falls flat*. The scientist, the curious citizen, and the machines are left to what could be gain out of the metadata exposed.

2.3. Serialization formats

A piece of information that proves useful for those searching a means to connect to the wealth of the data available is the format in which they will receive the data. Since the 90s of the last century and then following the widespread adoption of RESTful APIs after 2000, a lot of data serialization formats have been used.

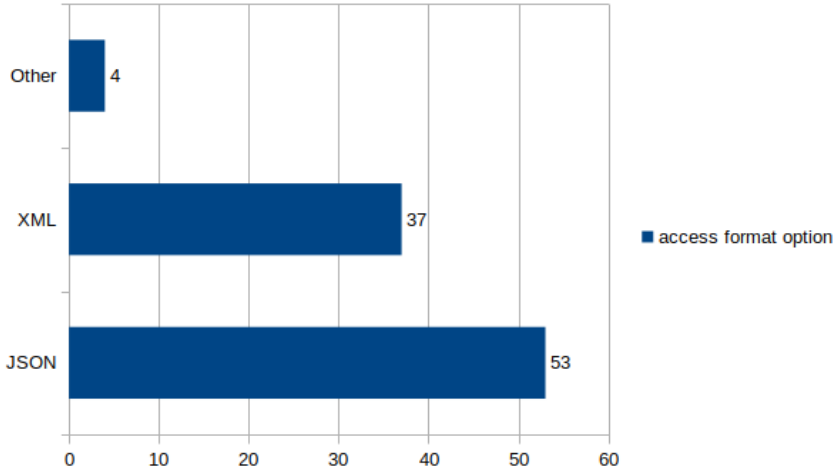

Figure 2: The format distribution as option to access serialized data

JSON format seems to be the format of choice as it is the one present as a choice for serialized data in all the analysed data APIs. XML is the second format present as an option to access the metadata. XML holds value due to the flexibility and already established web standards.

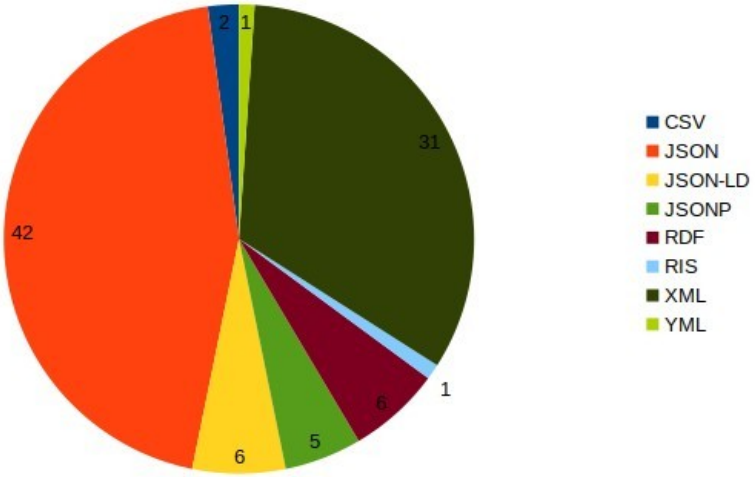

Figure 3: The extended view of the formats available for serialized data.

As evidence suggests (figure 3), JSON formats present some variations in the form of JSON-LD and JSONP in cases where more data needed to form a richer context.

It should be mentioned the fact that for the many of the APIs investigated, the response metadata could be requested in many different formats according to the needs of the caller. This particular aspect is a precious feet due to the versatility and adaptation to the user needs and diverse tooling.

2.4. Metadata schema and namespaces used

For the purpose of looking into interaction and interoperability, the samples of data obtained were investigated in searching of existing vocabulary reuse. Out of the lot, only eighteen provided easy identifiable namespaces in their metadata. The rest need a thorough future investigation as the sample data or the extracted ones under the created accounts have not yielded consistent results leading to a hastily conclusion of non-existence.

Name	**Namespaces**
arXiv API Access	atom
Springer Nature API portal	dc
Crossref REST API	rdf, dc, prism, owl, bibo, foaf
Digital Public Library of America	dc, dcterms, dcmitype, dpla, ore, rdf, rdfs, skos, owl,edm
Europeana API	dc, dcterms, ore, rdf, skos, owl, cc, foaf, rdaGr2, wgs84, edm
JSON/YAML for LoC.gov	dc
Chronicling America	dc, dcterms, ore, owl
Joint Research Centre Data Catalogue	dc, foaf, og, vcard, owl

Name	Namespaces
Elsevier Research Products APIs	prism, dc
Data.Bibliotheken.nl	rdf, owl
BnF API et jeux de données	dcterms, rdf, rdfs, skos, foaf, rdaGr2, srw, dc, onix
Open Data at the BnL	dc, dcterms
German National Library catalogues	dcterms
Kungliga biblioteket Library Database API	dc
The OpenAIRE APIs	oaf
OpenCitations	dcterms, rdfs, owl, foaf
Europe PMC	dc, dcterms, dcmitype
Open Library	dc

Table 1: Namespaces used in metadata

The variety of the namespaces involved in the metadata presented in the data is dictated by the profile and the mission of the institution where is considered as valuable to the outside potentially interested parties.

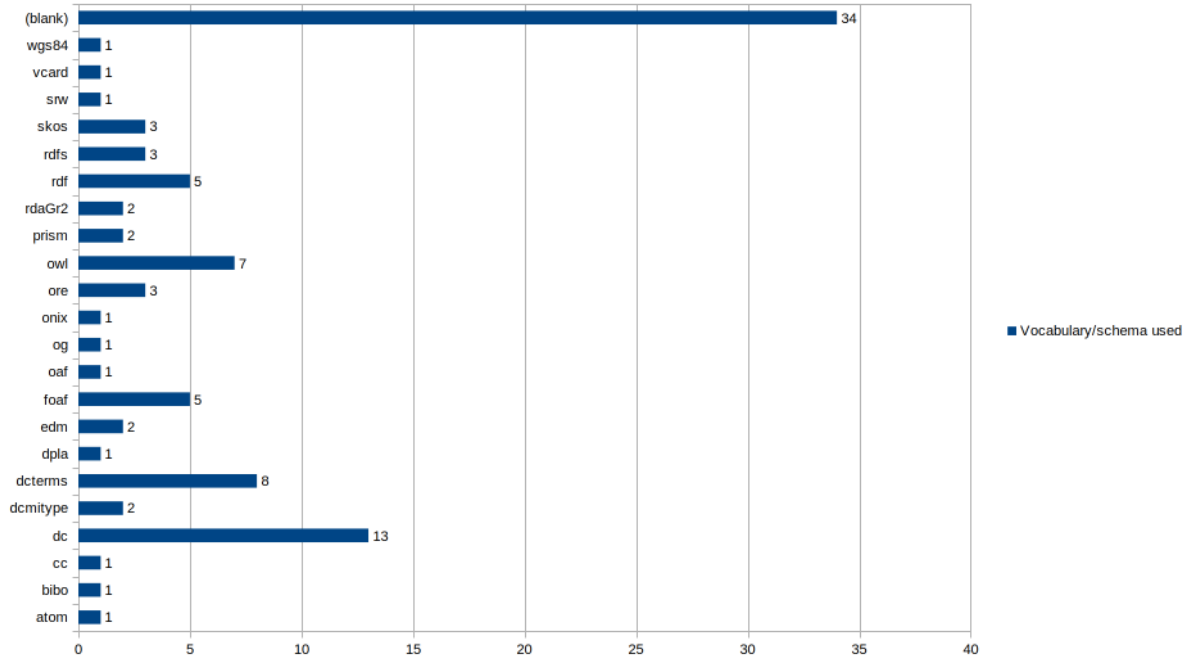

Figure 4: Represented namespaces in the metadata collected

Dublin Core is one of the main provider of vocabulary terms used in metadata construction. We do need to couple the namespaces used also in linked data representation as it is often the case of the providers who also manage a knowledge graph. Beyond the capable interrogation means SPARQL is presenting, when it comes to serialization of data, many of the present namespaces are present (owl, og, rdf).

Although the investigation revealed the namespaces used by most of the APIs, there are some which have not exposed any of the usual namespaces. As Table 1 shows the parties more interested in the reuse of the existing namespaces come from the Cultural Heritage sector. Digital Public Library of America even points out[3] the *Not Invented Here* syndrome that should be acknowledged for the betterment of the data users.

2.5. Common identifiers for the entities

One important aspect is addressing which identifiers are present in the records representing the digital objects or the ones that are referenced. An important key in which the following numbers should be read is that all of the records investigated present a localized identifier specific to the system used to produce or manage the metadata. Past this mention, the following figures reflect the identifiers used in the records for the digital objects described.

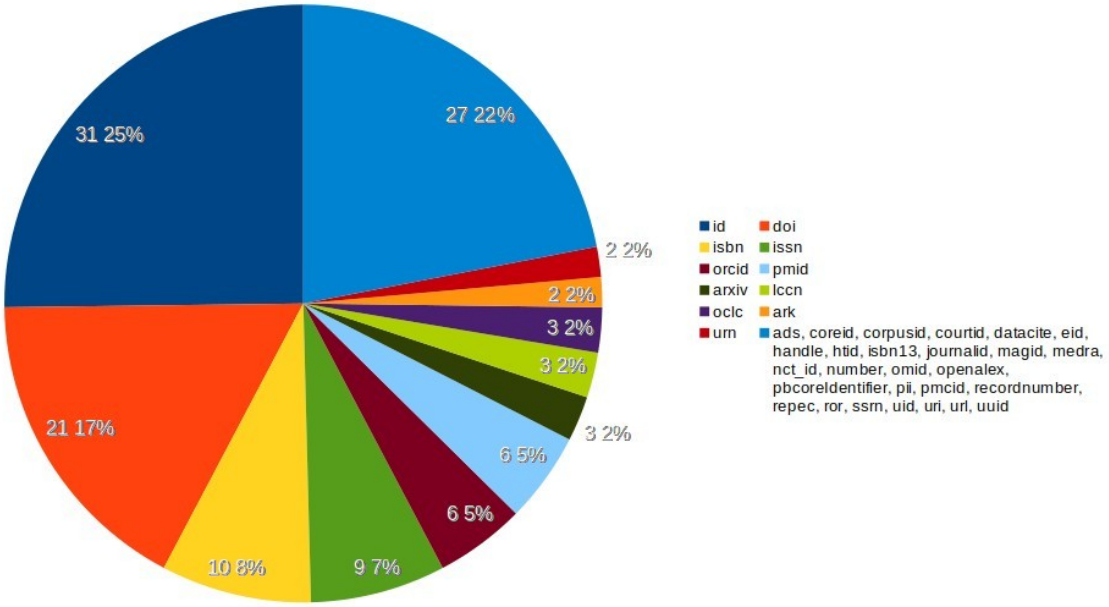

Figure 5: The identifiers present in the record representation of digital objects

Most of the internal ids (*identifiers*) used are alphanumeric sequences generated as a result of a cryptographic computation (hash). This is a perspective of what one is to expect finding in the metadata exposed by an API for a particular digital object described. may providers are designing their own id name schema, and some have applied cryptography (uuid). Further research is needed to determine weather the hashes are computed based on the content or any arbitrary seed content chosen by the creators of the records or is just what the adopted software solution gave by default.

[3] https://pro.dp.la/developers/philosophy

3. General details of the APIs in focus

All of the APIs expose a documentation where technical details are combined with useful descriptions of what an interested party is able to find through the endpoints. Some of the institutions go to great lengths including examples of calls on the endpoints involving primary minimal CLI tools like curl.

Some of the investigated API providers are actually building shell software over powerful indexing solutions like Solr or ElasticSearch, even on the base of these sophisticated ones which is actually Lucene. This decisions are factors that model the way requests are built, and this entails prescriptions on how data should be consumed as well.

All APIs give access based on a "recognition token" of sort. Some of them offer their API endpoints access based on an existing account where one should declare the way she/he integrates these with their own application. For the purpose of gathering data, this path couldn't be avoided. In case of The Lens, a 14-day trial access was granted to experience what the service has to offer.
All the API service providers present terms and conditions and most of them set limitations constraining the person or the machine to a certain behaviour in order to preserve the bandwidth and availability.

Although the service providers offer the endpoint, there are some of them who also make periodic data dumps available to download, a convenient strategy to expose all the data at once ready to be parsed and integrated in potential bigger data workflows.

4. API data exposure readiness of the trusted digital repositories

The role of the APIs is growing along with the infrastructure used to manage metadata. The infrastructure needs to satisfy the growing concerns on digital long-term preservation. For all the research conducted under Horizon 2020, the researchers need to deposit the papers (*in a machine-readable format*) and data in “trusted repositories” according to the Article 17 of the Model Grant Agreement (Annotated Grant Agreement[4]). This requirement is also permeates into the publication guidelines of Open Research Europe[5], the European Open Access publishing service offered to the researchers involved in Horizon 2020 project.

For this reason, the dataset provided by the CoreTrustSeal has been taken under scrutiny. CoreTrustSeal is a set of requirements for repositories bearing the complete name CoreTrustSeal Trustworthy Digital Repository (TDR) Requirements. This is the collaborative effort of Data Seal of

[4] https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/common/guidance/aga_en.pdf accessed from https://webgate.ec.europa.eu/funding-tenders-opportunities/pages/viewpage.action?pageId=1867974 (Dissemination & exploitation of project results)

[5] https://open-research-europe.ec.europa.eu/for-authors/data-guidelines

Approval (DSA) and World Data System a part of International Science Council (WDS) working together under Research Data Alliance (RDA). This is a tool by which digital repositories are analysed if are abiding to the specifications. As long as all criteria are met, the digital infrastructure is declared able to provide long term preservation services.

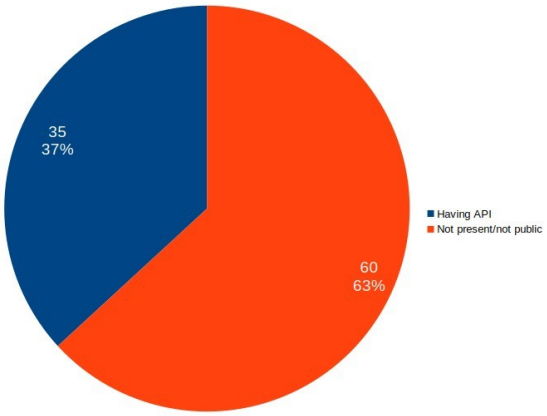

Figure 6: CoreTrustSeal Repositories exposing an API

The data tell an interesting story on the importance of developing and maintaining an API. Almost a third of the CoreTrustSeal repositories have an API. The rest of them have no public endpoints.

Another very important aspect concerning this analysed set is that most of the software solutions are in house developments. This is almost surprising because one would expect more open source or proprietary implementations.

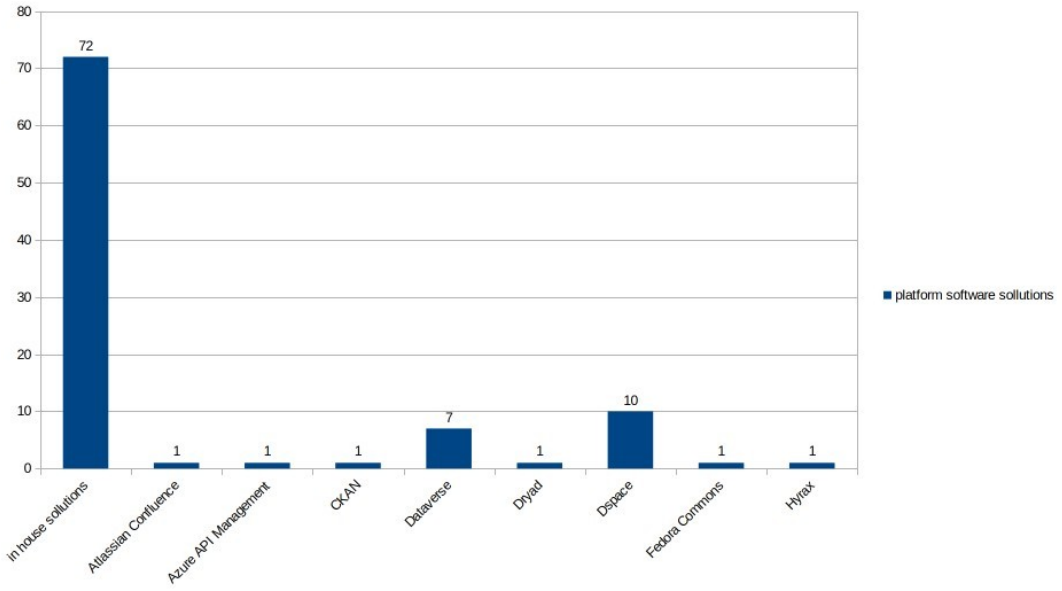

Figure 7: Platform software solutions

The data shows a preference for DSpace and Dataverse integrations for those who went on adopting an open source solution.

5. Conclusions

The APIs investigated revealed some common traits and different degrees of existing protocols and policies. All of them are using HTTP protocol to provide access. Twenty years after Roy Fielding proposed model, the APIs are an established means of exposing the data for any interested party, let that be human or machine. The information obtained from the analysis could be the support for those planning to develop a dedicated data access service. The APIs investigated offer access to metadata. The data you may access is actually metadata representation of the actual digital objects for the obvious reasons concerning size and practicalities related to sending large sets over the wire. Even the bulk downloads are consistently metadata data sets. The metadata used to represent the digital objects is varying from outlet to outlet. An integration of these data sources in workflows is hard to obtain due to heterogeneity. Identifiers are minted according to the organisation needs. Digital Object Identifier is the most important identifier adoption wise.

Although Digital Object Identifiers are used on large scale, the permanent identifiers are a secondary means of identification next to the internal id. Most of the internal ids used are alphanumeric sequences generated as a result of an cryptographic computations. This study is also useful for all the digital repositories who follow the REST API first approach.

The Open Science Monitor[6] is an official instrument used to track what changes are occurring in Europe and the world at large. In the section dedicated to *Data on open collaboration*[7] there is an interesting trend to observe with regards to the growth of research APIs.

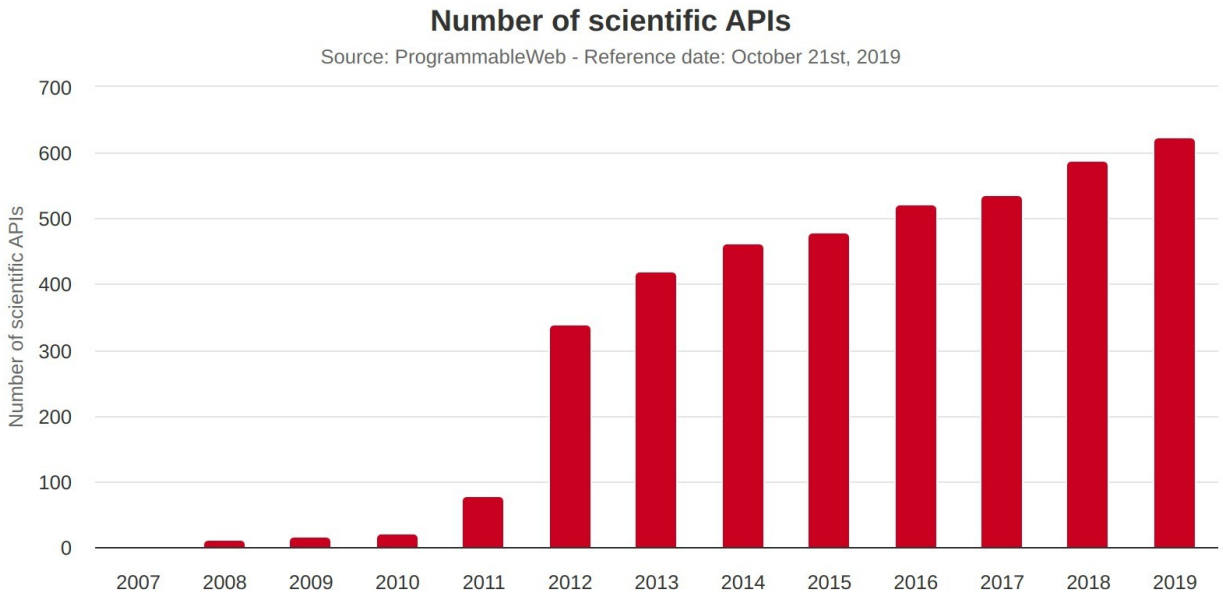

Figure 8: The growth of scientific APIs until 2019 - ProgrammableWeb data

Although, the data was obtained from the now disappeared ProgrammableWeb, a portal where data on existing APIs was kept updated, the growing trend must have been kept at the highest level due to the growing need for data in processes concerning machine-actionable data.

As a further useful development, an investigation into the re3data.org dataset to uncover those who expose APIs[8] according to the criteria developed in this study.

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