Recuperação da Informação e Pesquisa como Processo de Aprendizagem: um estudo de caso no contexto da Covid-19

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Resumo: Este artigo propõe um estudo de caso para analisar o processo de recuperação de informação e a busca como um processo de aprendizagem em um ambiente de busca sobre Covid-19. Como metodologia de pesquisa, o trabalho analisa um grupo de participantes, verificando seu nível de conhecimento sobre a Covid-19, antes e depois de pesquisas na web. O estudo inclui uma análise do efeito Dunning-Kruger, experiências metacognitivas e uso de consultas na web. Os achados desta pesquisa correspondem à observação de um padrão semelhante nos testes realizados com o efeito Dunning-Kruger, e também um aumento na estimativa das notas do segundo teste nas séries mais altas, em uma população com diferentes níveis de escolaridade e faixas etárias. Observa-se que, mesmo quando os usuários navegam nas mesmas consultas, ainda existem dificuldades e limitações no avanço do conhecimento nos ambientes de busca. É importante destacar que esta pesquisa analisou uma situação específica, que envolve informações sobre Covid-19, interesse de pessoas de diferentes escolaridades e idades, bem como o grande volume de informações, notícias falsas e dificuldades em analisar informações, ao contrário de experimentos em outras pesquisas analisadas. Por fim, este estudo de caso abre a porta para novos focos e oportunidades de experimentação no processo de recuperação de informação.

Palavras-chave: Recuperação da informação; pesquisa como aprendizagem; Dunning-Kruger; metacognição; Covid-19.

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Information Retrieval and Searching as a Learning Process: a case study in the context of Covid-19

Abstract: This paper proposes a case study to analyze the process of information retrieval and the searching as a learning process in a search environment about Covid-19. As research methodology, the work analyzes a group of participants, checking your level of knowledge about Covid-19, before and after a web search. The study includes an analysis of the Dunning-Kruger effect, metacognitive experiences, and use of queries on the web. The findings of this research corresponds the observation of a similar pattern on the tests realized with the Dunning-Kruger effect, and also an increase in the estimate of grades in the second test in the highest grades in a population with different educational levels and age groups. It is observed even when the users browser the same queries, still there are difficulties and limitations in the advancement knowledge in the search environments. It is important highlighted this research analyzed a specific situation, that involve information about Covid-19, interest of people of different schooling and age, as well as the large volume of information, fake news, and difficulties in analyzing information, unlike experiments in other analyzed researches. At the end, this case study opens the door to new focuses and opportunities for experimentation in the process of information retrieval.

Keywords: Information retrieval; searching as learning; Dunning-Kruger; metacognition; Covid-19.

1 INTRODUCTION

The internet is one of the most used sources to search for knowledge. Learning is inserted in the search process and in all aspects of the lives of individuals (Wu *et al.*, 2018). Search engines have invested in better approaches for more efficient results. Such tools may work well for certain types of basic research tasks, but they do not support more complex tasks, for example, searching for learning or investigation. In other words, the search tools are more optimized to assist in factual learning than in other types of learning, such as understanding, analysis, application, or synthesis (Fulantelli *et al.*, 2016).

The *Searching as Learning* (SaL) area aims to study the synergy between both the process of searching and learning (Vakkari, 2016), treating such processes as a human process (Machado *et al.*, 2019) that consists of multiple query iterations and return sets of items that require cognitive processing and interpretation. The information seeker needs several cognitive, mental and physical skills to build knowledge and gain understanding (Deja and Rak, 2019). There has been a movement in recent years with a variety of special periodicals, workshops and research articles with problems and challenges regarding SaL (Liu and Jung, 2021). Much of the research time in the learning tasks is devoted to the analysis and comparison of results, as well as to the reformulation of queries (White and Roth, 2009).

For building a tool under the SaL's precepts it is necessary that it can assist users in their learning tasks, with improved information ranking and retrieval processes (Hoppe *et al.*, 2018). In addition, it must allow accurate detection and prediction of learning needs and their scope. The search tools aimed at children, for example, due to the protection filter, remove important results for students. On the other hand, traditional tools, with or without protection filter, return inadequate results and of average knowledge levels, being superior students' understanding (Anuyah *et al.*, 2019). There is a search to find ways to evaluate the progress of learning in an efficient way to research "how to learn", which is a good strategy for a pedagogical architecture (de Alcantara Gimenez *et al.*, 2020).

Some searches as a process of learning are carried out in news organizations that disseminate information continuously in support of the various social media that accelerate the consumption of this news. In the same way that the diffusion of social media increased the degree of clarity and the democracy of sharing scientific data, we had a noise of the

dissemination of information added to particular beliefs and opinions (Orso *et al.*, 2020), generating fake news. In addition to the ability of people to create information, we have the search for users to understand, generate knowledge and awareness of needs, essential elements for understanding behavioral information (BI) (Deja and Rak, 2019).

In this context of information seeking, finding knowledge about health becomes more and more important, however, identifying the most relevant ones becomes a difficult task, because searching from different sources is necessary (Chen *et al.*, 2020), especially in an environment of fake news like Covid-19 case. As the last article pointed out, "cognitive barriers" (Savolainen, 2015), difficulties in selecting appropriate search queries (Savolainen, 2015) and identifying differences (Zhang *et al.*, 2015)" can still be difficult factors to search health information.

This article proposes a case study to analyze the effects of learning in a search environment using learning about Covid-19 as a study scenario. The choice of the theme is due to the topicality of the subject, the interest of people of different schooling and age, as well as the large volume of information, fake news, and difficulty in analyzing information about that disease. One of the challenges for a SaL studies is to identify behaviors and thus make it possible to detect and predict user needs in the process (Hoppe *et al.*, 2018). The study, therefore, aims to answer:

- **Q1**: Do the current web search engines allow the learning process to occur in complex context as Covid-19?
- **Q2**: How do conditions such as prior knowledge, accessed sources, among others, affect the SaL?

The article is organized as it follows. Section 2 presents the works related to this research. Section 3 details the research methodology employed in this work. Sections 4 and 5 present and discuss the results and our final considerations, respectively.

2 RELATED WORKS

SaL studies analyze the effects, difficulties and cognitive skills of students in search engines. In (Kammerer *et al.*, 2018; Demaree *et al.*, 2020), the authors carried out surveys on the behavior and search path of users in search engines, comparing with mobile and desktop environments. Other analyzes behaviors involve the detection of activities by analyzing logs (Yu *et al.*, 2018) and the use of eye-tracking technologies to identify results preferences in video or text format (Pardi *et al.*, 2019), and for health information research (Gwizdka *et al.*, 2019). (Chen *et al.*, 2020)

investigates queries related to behavioral actions and conceptual changes and skills in research inthe process of learning about health information. As an example for IB, (Deja and Rak, 2019) investigates the influence of mentalism in collaborative and individual behavior of information among the academics.

The methodologies for verifying knowledge gains in the use of search engines have similarities in the SaL literature. The two-step knowledge verification (before and after the search process) is the most common method. An analysis of how the student's prior knowledge interferes with his search behavior was carried out in (Karanam and van Oostendorp, 2016), in which the ability of two groups of health professionals, with different levels of knowledge, to make correct diagnoses using search engines was verified. The study showed that the group with the most experience had greater mastery in this task by making use of more specialized sources for the task. This conclusion is also shared by other authors (Davari *et al.*, 2019). In (O'Brien *et al.*, 2020), the authors found that more knowledgeable users tend to have less difference in grades between the two tests.

On the other hand, in (Roy *et al.*, 2020) it was found that users with less knowledge obtained an improvement inferior to those who already had substantial knowledge. In turn, in (Gwizdka and Chen, 2016) it was indicated that the knowledge acquired is greater the more queries the user makes and not the more pages he reads. There are also studies on the evaluation of knowledge of SaL involving groups such as (Xu *et al.*, 2020) evaluating those involved during the experiment. For a better understanding of this process, the present work presents an analysis of the effect of prior knowledge in the search process, comparing groups of specialists and groups of non-specialists, differently from other works in the literature. The analysis was carried out verifying search terms, reading time and search sources and their effect on the marks acquired in the knowledge tests. Still, the study scenario of this work allows verifying the user's discernment to recognize fallacious texts that are inevitably returned by the search engine during the learning process.

The analysis of the Dunning-Kruger Effect (DKE) is important in experiments in the area of education and psychology. The DKE indicates that people with a lower level of knowledge tend to overestimate their income due to the inability to analyze the breadth of their knowledge, on the other hand, people with greater knowledge tend to underestimate their knowledge (Dunning, 2011). This is due to the greater ability to analyze whether they are getting it right or

wrong and that is why they believe that others will also be getting it right, because they do not see their successes as special.

Recent works, such as (Fano and Graziani, 2020), recognize characteristics of this effect in the study on radical ignorance, which the authors define as the user's lack of knowledge about their own ignorance about the topics of knowledge. In addition, (Tibau *et al.*, 2019) explains that it is common to have prior ignorance and information uncertainty and this is called the Anomalous State of Knowledge (ASK), which is related to the inability to accurately specify the individual's information needs. In (Zhou and Jenkins, 2020), the authors used DKE data to verify facial expressions related to confidence in the tests.

The only work that discussed the effect in the context of SaL is the work of (von Hoyer *et al.*, 2019), which made use of two-stage knowledge tests in learning about climate effects in a group of university students. In the present work, an analysis of the DKE was carried out using a population with different educational levels and age groups, covering a more representative population of search engine users. In addition, it is compared if there is a difference in the behavior in relation to groups of specialists and non-specialists.

3 METHODOLOGY

The experiment aims to analyze the positive effects and difficulties of the participants with a learning process in search of a recent topic. Search engines do not support more complex investigative research tasks (Fulantelli *et al.*, 2016). For this reason, a study of the learning process was planned using the context of Covid-19, which verified a great presence of fallacious texts on the internet (de Sousa Júnior et al., 2020; Orso et al., 2020), which makes the learning process more difficult, and allows the observation of the shortcomings of the search engines in relation to the learning process. Still, as it is a topic that many people have been informed about for health reasons, experiments with a heterogeneous population were allowed to be carried out. The information collection process was carried out using a Google Form and invitations to participate in the research were posted on social networks. Participants were instructed to approve the consent form, inform their level of education, their area of activity and age.

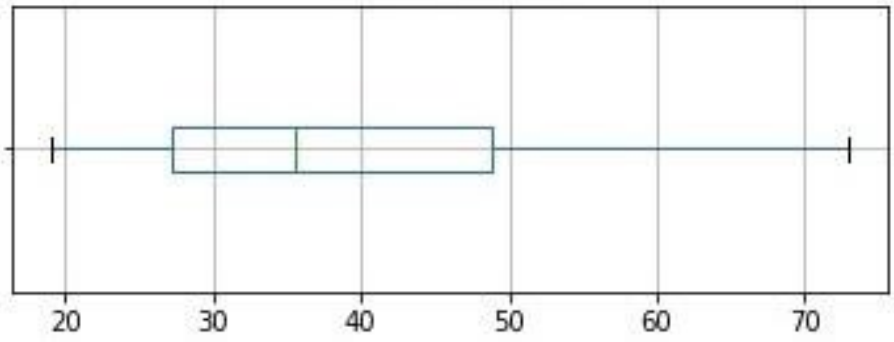
The experiment was comprised of four stages. In the first stage, participants were asked to answer a set of 10 multiple-choice questions on issues related to the pandemic. Then, they were provoked to search the Web to find out about topics that they felt unsafe in the questionnaire. Subsequently, the participants answered a new assessment of 10 questions about the pandemic.

Finally, open-ended questions were asked for the participants to identify their behavior throughout the search process and throughout the study, in addition to the sources of information. The participant informed the start and end time of the first three stages. Also, for each questionnaire, the participant should answer his / her expectation of grade immediately after answering it, using the Likert scale.

Users in some stages and at the end of the experiment gave their opinion on their own experience in the process. The written reports and opinions enabled the analysis and classification of the metacognitive facets in this article. Subsequently, the participant was confronted with his real grade. Due to the social isolation of the pandemic, the experiment was carried out online and without the possibility of supervision.

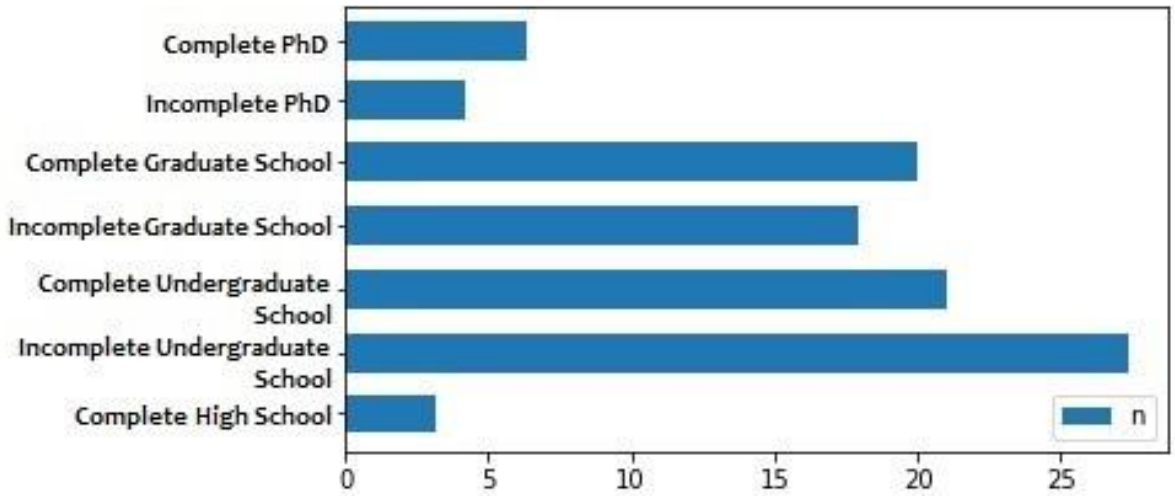
The questionnaires were built with the objective of assessing the level of knowledge of the participants in relation to the disease, which provided for knowing correct forms of prevention, symptoms, use of medications, in addition to discerning fake news, which were very frequent during this period. During the questionnaires, participants were asked not to consult the Web, as they should only use searches in step 2. Information was collected from 104 participants during 10 days of research and 95 responses were considered valid for the final analysis after exclusion of 9 outliers. To identify the outliers, three variables were verified: final grades in the first and second questionnaires (test 1 and 2, respectively), duration in test 1 and duration of the user's survey. Thus, four responses showed anomalies in relation to the score in test 1 and two in test 2. Only one answer was excluded due to the duration of test 1 and one due to the duration of the survey. In Figure 1, the age range of the participants is shown and the percentage of participants per schooling on the Figure 2 (the level of education has been adapted to the American model). There is an expressive participation of people with schooling between incomplete graduation and complete graduate education (86.32%). In addition, there was the participation of people from different age groups, ranging ages from 19 to 73 years.

Figure 1 - Distribution of the participants' age range.



Source: prepared by the authors.

Figure 2 - The percentage of participants by level of education.

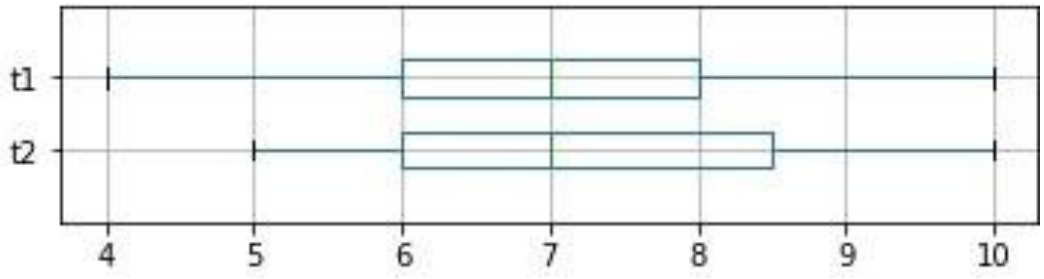


Source: prepared by the authors.

4 RESULTS AND ANALYSIS

When analyzing the scores of the two tests, a small improvement is noted between the first test (T1 - mean: 7.16; standard deviation: 1.59) and the second test (T2 - mean: 7.34; standard deviation: 1.38). In T2, there were a greater number of people who had a maximum score between 6 and 9 in relation to T1, and there were no participants who obtained a score less than 5. On the other hand, three people obtained a maximum score in T2, while that number was six participants in T1. It is observed in the notes dispersion graphs (Figure 3), that there is a subtle improvement between the tests. There is a correlation analysis between the search time and the difference in grades between T1 and T2 using the Spearman test resulted in an r = 0.02, which shows that the search time is not enough to infer a greater (or lesser)) user learning. For differentiating the behavior of users in the analyzes below, the results are separated into different groups: data from participants who identified themselves as specialists in the health field (12.63 %) and the others (non-specialists), which are identified here like G_e and G_e. The average total response time to the form was 26 minutes, with a standard deviation of 14 minutes.

Figure 3 - Box plot of grades distribution between T1 and T2.



Source: prepared by the authors.

4.1 Search terms and sources

To determine whether prior knowledge of the research topic can influence search behavior and results between knowledge tests, an assessment of the terms searched was carried out. The terms were divided between the groups G_e and G_e. Then, the terms were grouped into categories according to their semantics. Table 1 shows the categories and examples of terms associated to them.

Table 1. Search term categories (originally in Portuguese)

Category	Example of query
C0. General terms	*covid covid-19 coronavirus*
C1. Consultation with official bodies	*WHO coronavirus SUS ministry of health anvisa*
C2. Verification of fake news	*bleach laboratory forklift*
C3. News	*coronavirus situation wuhan usa countries*
C4. Treatment and Prevention	*coronavirus prevention recommendations*
C5. Historical information	*coronavirus bat, covid origin, china*
C6. Statistical data	*covid-19 deaths cases underreporting*
C7. Contextless searches	*chemist G1*

Source: prepared by the authors.

Category	Example of query
C0. General terms	
C1. Consultation with official bodies	
C2. Verification of fake news	
C3. News	
C4. Treatment and Prevention	
C5. Historical information	
C6. Statistical data	
C7. Contextless searches	

The C0 category contains searches carried out containing only general terms in relation to the research topic. Approximately a half of the search attempts by participants in the Ge and Ge groups were in the C0 category. It was found that these represent the participant's initial searches, being followed by other search attempts using sequences of terms from the other categories, which indicates an expectation that

the search engine will meet the user's need for information, even with very general terms, followed by a sequence of more refined search attempts.

The ratio between the arithmetic mean of the category terms per individual in G_e and G_e and the total of terms searched to identify search behaviors between groups were calculated. It is possible to observe in Figure 4 that participants from G_e performed more frequently searches that allow access to more reliable information (category C1). Basic information such as treatment, prevention and historical information was little sought by this group, which denotes a previous knowledge of the participants of the group of specialists in the health area. The group G_e, in turn, did not seek much for information from official bodies and there was a greater number of searches, compared to the previous group, for historical, preventive and statistical information.

Figure 4 - Heat map of the distribution of terms by categories between the groups Ge and Ge.

Source: prepared by the authors.

Participants were asked to inform the sources of information used for reading and these were subsequently categorized among news texts, blogs, videos, official organizations and bodies, Wikipedia, search engine snippets, social networks and others. It was noticed, in the group G_e, the use of fewer types of information sources, while the group G_e was more frequent when consulting sources of different categories, which may indicate, as in (Davari *et al.*, 2019), that prior knowledge on the subject may result in fewer sources being sought, and in turn, less effort in the search. In both groups, there was a large number of accesses to news texts and websites of organizations and governments, which can lead to more relevant information on the subject. However, the use of social networks and blogs was also high. Although some of these types of sources seek to combat disinformation, through alerts on the subject (de Sousa Júnior et al., 2020), some of the sources used tend to be disseminators of fallacious information, which can interfere negatively in the learning process. It is worth noting that many participants used

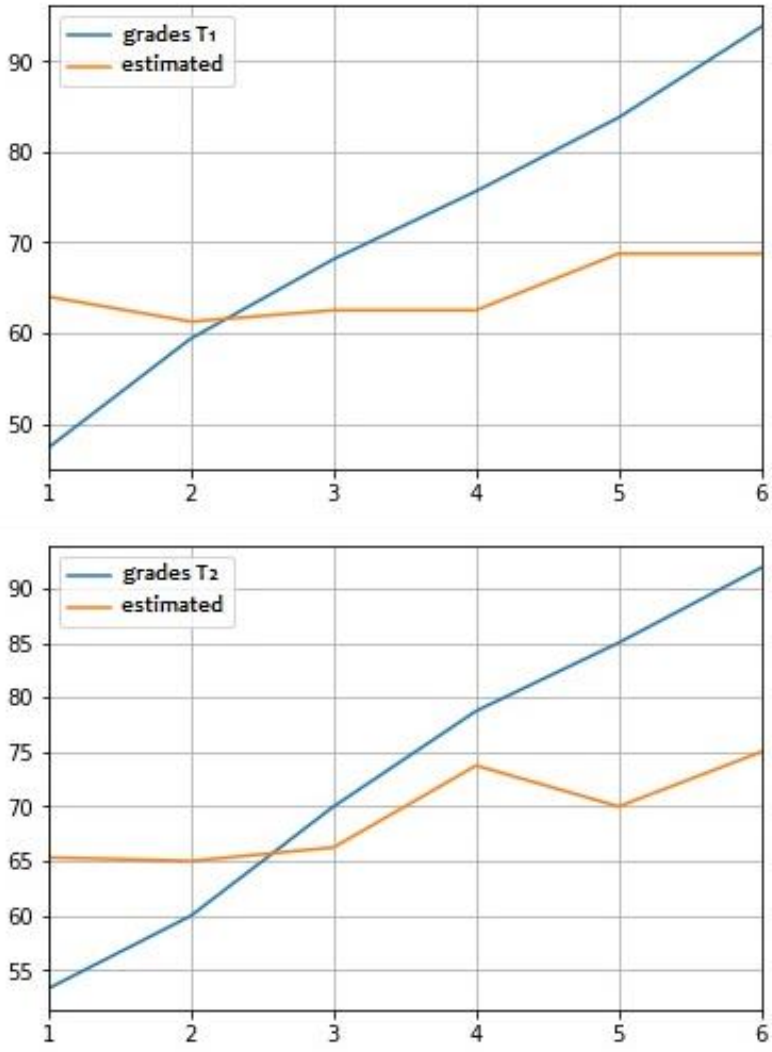
snippets as sufficient sources of information on the subject, which denotes the user's confidence in summarizing the topic presented by the search engine itself.

When comparing the results of the questionnaires between G_e and G_e, it was found that G_e obtained a result, on average, greater than G_e, but a gain lower average (difference betweentest scores). As the questionnaire was created with general questions, it is noted that, although the group G_e uses less effective search terms, they are still able to find sources with factual information on the subject and obtain gains from knowledge. However, for users with greater knowledge on the subject (G_e), such factual information is possibly already known, thus reducing the potential for gaining knowledge in this type of experiment.

4.2 Dunning-Kruger Effect (DKE)

For verifying the DKE, an analysis was applied on the two tests between the grades and expectation of knowledge level collected by the participants, on an absolute scale. The population was organized in sextis in ascending order of grades. For analyzing DKE in the graphs (Figure 5), it is noticeable that both in T1 (left) and T2 (right) there is a crossing of blue and orange lines, the first being the average of scores in each sextile and the second the average estimate of grades in each sextile. To the left of the intersection we have an overestimation of the worst evaluated and the right to an underestimation of the knowledge of the best placed. If this did not happen, the orange line would be totally above (everyone overestimated) or it would be totally below (everyone underestimated).

Figure 5 - The Dunning-Kruger effect on the graphs (T1 is on the top and T2 is below).



Source: prepared by the authors.

The graph shows that at T1 the first sextile overestimated 16.67%, the second sextile overestimated 1.88%; in T2, the first sextile overestimated 12% and the second sextile overestimated 5% difference. The rest of the population in both tests underestimated their results (T1: 3/6 - 5.63%; 4/6 - 13.13%; 5/6 - 15%; 6/6 - 25%; and T2: 3/5 - 3.75%; 4/6 - 5.0%; 5/6 - 15%; 6/6 - 16.88%). It is observed that the scales of the two graphs are relatively different and the estimate of scores in T2 were slightly higher than in T1. The average estimate scores were also higher at T2 (mean: 69.26) than at T1 (mean: 64.63).

In (von Hoyer *et al.*, 2019), the authors claimed that there was a slight tendency for excess placement in the second test, with the improvement in grades between T1 and T2 being slightly more noticeable than in the present experiment. This relationship shows the improvement of

the participants between the tests was smaller and the estimate too. In (von Hoyer *et al.*, 2019) the improvement was greater and the estimate also went up a lot. This may be an effect that the SaL process improves the appraised person's perception of their improvement in learning and self-assessment ability. This is consistent, as (Dunning, 2011) claims that it is possible to change pre-existing self-views about your level of knowledge by activities or types of questions.

4.3 Signs of metacognition in the search process

Similar to the work of (Crescenzi, 2016), this work aims to analyze and find aspects of metacognition during the activity, which can be found in the reports of the participants. Unlike that study, here an analysis is made on the effects of SaL on a current topic, which requires greater effort from participants to identify the information returned by the search due to the presence of fake news. In this experiment, users were motivated to describe their experience with the search in two moments: immediately after the web search and at the end of the test. In order to analyze the comments, due to similarities to the reported experiences, they were grouped thus to facilitate the study of the present metacognitions. After the grouping, relationships were created with the summarized classification of facets of metacognition and its manifestations presented by (Efklides, 2006) who, in his article, analyzes metacognition in the online learning process. The metacognitive facets that are of interest to the process are related to experiences (especially feelings, judgments and expectations), skills to deal with the activity and applied knowledge.

The reports were short and usually expressed only one feeling or observation that was relevant to the participant. It was found that many (29.47%) performed analyzes and judgments on their knowledge, on the quality of information, on search engines and evaluated the result of the process. This type of report also involved knowledge, experiences and metacognitive skills, in some cases, strategies to seek were still highlighted. A very representative comment from this group was: *"For confirming my answers from the first phase, I was specific in the searches. The first Google results already answered me what I wanted to know. In most cases, I did not access the returned page, I relied only on the abstracts and titles but analyzing where those results were coming from."* Thus, it can be seen that approximately one third of the participants reported perceiving their search method, which reports covered the certification of the reliability of the data sources returned by the searches, a high confidence in the automatic responses returned by the search engine (snippets) and content descriptions of links on websites that were familiar to the participant. Thus, search engines are responsible for influencing the user's learning,

allowing a more summarized access to information, which can also bring losses to the process when the user has little investigative skills on the topic under study. It is emphasized here that the average search time of users was 7.68 minutes, which does not represent a long duration of the investigation stage.

Approximately 25% of the participants described that, when researching, they were surprised by new information they found in the search. This demonstrated new knowledge accumulated by these participants, thus having a development in the participant's memory and a feeling of knowledge. Of the comments, 22.11% of the participants declared some type ofdifficulty, related to the search engine or regarding the identification of useful and true information. These comments are related to metacognitive experiences of feeling of difficulty and effort estimation. Usually, this sensation is associated with negative effects (Efklides, 2006). On the other hand, a judgment of the task's difficulty may be an analytical judgment of the task's resources (for example, complexity), which is not identical to what the person experiences as an ease of learning or feeling of difficulty. Several comments had short phrases reporting ease or tranquility with the process (18.95%) and a group (17.9%) that showed disinterest in the task or did not present any type of report. Most of these groups represent users who were familiar with the subject and obtained good marks in both tests. Part of the group, however, is associated with a lack of engagement by the participant with the experiment, which was the result of the effort required to complete all study tasks. Since the experiment was conducted remotely and without supervision, it is reasonable that part of the participants did not spend the effort or attention that was expected to complete all tasks.

In the final reports, many comments were related to congratulating the work, thanking the experience and analysis about themselves or about the situation of Covid-19. Some comments talked about having been long or about the difficulty in answering something, but some become interesting to understand some particular cases. With that, we see many characteristics of metacognitive experience about time estimation, learning feelings, satisfaction, difficulty, in addition to judgments and analysis.

4 CONCLUDING REMARKS

This work presented a search process using a current subject (Covid-19) as a case study with an analysis of behavior, efficiency and results in the learning scenario. An improvement in the performance of the participants was detected between the tests. However, this increase was

little correlated with the search time. Maybe, that happened in consequence of the low supervision imposed by the isolation of the pandemic at that time. It was also found that many participants used vague terms that led to limited access to important sources of information that couldassist the study of these participants, which shows that the search engines, although they are important tools in the search for information, still need to be adapted with new functions when used for a learning process.

Even with the positive reports of the participants showing signs of metacognition during the search, they presented difficulties in the search systems, demonstrating that the mechanisms are still not enough to support learning. This difficulty can be observed with the similarity of terms and search sources between those who have improved and those who have not even been successful. Therefore, even when browsing the same search terms, there are difficulties and limitations in the advancement of students' knowledge in the search environments. Since the subject (Covid-19) is recent and surrounded by questionable sources, it highlighted this lack in search systems in support of learning, which differs from previous SaL works that addressed learning of established topics, such as basic mathematics. In this regard, new resources and techniques associated with search environments that identify the reliability of sources for learning purposes could assist in this matter and that can be a promising subject for future works in SaL.

The results showed that DKE was present in both tests. Comparing with the work (von Hoyer *et al.*, 2019), a similar pattern on the tests is observed and an increase in the estimate of grades in the second test in the highest grades. However, in the present study, the effect was identified in a population with different educational levels and age groups, thus being more representative of users of search engines. Although, new experiments are still important to confirm that the SaL process improves the appraised person's perception of their improvement in learning and self-assessment ability, as this study indicates this.

For future developments, it is necessary to increase the current search systems to increase student support and compare with standard systems. Metacognition analyzes are important to verify the positive and negative points of a learning process and should be considered in new works. The Dunning-Kruger Effect analysis process is an adequate method to be used in other research to infer patterns and cognitive abilities in SaL works. New work on learning on current topics and knowledge that is not widespread can be carried out. Some of the limitations of this

study can be overcome in new studies, such as the lack of supervision by participants and the use of search logs and user interaction with the search interface.

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