



Teens' Conceptual Understanding of Web Search Engines: The Case of Google Search Engine Result Pages (SERPs)

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Abstract. We explored teens' (aged 15–17) conceptual understanding of search engines (SEs), emphasizing search engine result pages (SERPs). In an online survey, we asked teens to articulate how a search engine (SE) finds, generates summaries of, and ranks search results; identify the structural components of search results; comment on learning in school about SEs; as well as provide suggestions for improving SEs. Of one-hundred and ten teens, twenty-two completed the survey. Analyses revealed that teens' conceptual understanding of SERPs is more perceptual than conceptual and guided by incidental and experiential learnings rather than systematic instruction in school. We found a gap between teens' understanding of the design and representation of the structural components of search results and Google designers' conceptual model (interface design) of these components, suggesting the need for design that is more transparent and with better affordances and signifiers. Teens suggested three categories of design improvements in Google (SERPs, Search and Retrieval, and Privacy) in support of enhancing their experiences. Practical and theoretical implications are discussed.

Keywords: Search engine result page · Teenagers · Children · Information retrieval

1 Introduction

People's conceptions of how a system works guide their interaction behavior [1]. Search Engine Result Pages (SERPs) display listings of search results in a ranked order. Part of a search result is the summary or snippet, which is a description of or an excerpt from the webpage... or the description portion of a search listing," excluding the title and URL address (<https://searchengineland.com/anatomy-of-a-google-snippet-38357>). Search engines (SEs) generate search engine result pages (SERPs) in response to search queries. SERPs play a key role in user interaction, experience, and success. Numerous studies have paid attention to various aspects of SERPs, including effectiveness of summaries [e.g., 2, 3]; length [e.g., 4, 5]; modified layouts [e.g., 6, 7]; utility and cost [e.g., 8], and readability [e.g., 9, 10]. Much of this research concerned adult users.

Work that focused on young users (children, pre-teens, and teens) has examined their interaction with SERPs, including click behavior [e.g., 11, 12]; reading strategies [e.g., 13, 14, 15, 16]; and query formulation and reformulation [e.g., 17, 18, 19, 20, 21]. Studies have also addressed young users' relevance judgment and credibility assessment of web information [e.g., 22, 23, 24, 25, 26, 27, 28, 29]; and collaborative information seeking on the web [e.g., 30]. Researchers have developed child-centered query suggestion assistance to support effective query formulation in SEs [e.g., 31, 32, 20]; while others designed child-centered interfaces [e.g., 18, 33, 34]; and assessed the readability of SERPs [35–37].

Understanding young users' web knowledge is important. As [28] found, young users' (aged 11–18) belief that a website is a hoax site significantly influenced their credibility assessment of websites. Similarly, believing that the web has accurate information significantly influenced how students select relevant search results [6]. One may assume that due to high exposure, today's teens possess good understandings of SEs. Nonetheless, to the best of our knowledge, no studies validate this assumption. In the present study, we explore teens' conceptual understanding of key aspects of SERPs, including how SEs find, create summaries of, and rank search results; identification of the design components of search results on SERPs; as well as learning in school about SEs. Additionally, we elicit teens' suggestions for improving the design of SEs with a focus on Google.

The findings have implications for providing innovative pedagogical SE literacy programs in schools to support teens' understanding and knowledge. They also serve as a new lens to inform the transparency of Google interface design and representation of SERPs. Finally, the findings have theoretical directions for examining teens' conceptualization of SEs in combination with their interaction behaviors with SERPs, an area that has been under-investigated.

2 Background

2.1 Conceptual Framework

Exploring teens' conceptual understanding of SEs and aspects of SERPs is situated within the user-centered design perspective [1]—that is, the extent to which a user's conception of a system matches with the designer's conceptual model of the system. Explicably, a mismatch could create difficulties, confusion, error, and uncertainty for the user, especially when the design of the system is not transparent [1]. Thus, exploring teens' understanding of the design and representation of SERPs will reveal whether such design provides affordances and signifiers [1] that are self-explanatory or self-evident [38] for teens, and subsequently, informs of whether a gap exists between the teens' epistemic knowledge of SERPs, particularly the components of search results, and the designer's conceptual model of these components.

2.2 Design and Representation of SERPs

Numerous studies focused on improving SERPs to support user interaction. One strand of research examined users' reactions to SERP information organization. For example,

[39] organized web search results into hierarchical categories using text classification algorithms and found that participants liked the category interface much better than the list interface and were 50% faster at finding information organized into categories. [6] compared a grid format list to a standard list format, concluding that users of the grid interface spent an equivalently long time on all search results, whereas users of the list format spent most of the time examining top results.

Another strand of research investigated how users reacted to SE summaries or snippets. Studies generally concurred that participants preferred longer result summaries, and these were perceived to be more informative than shorter ones [5, 40]. [4] created three search interfaces that varied by number of SERPs (i.e., three, six, and ten). They found that those who interacted with three results and six results per page spent more time viewing the top-ranked results than those who interacted with ten results per page. [5] designed four layouts of SERP snippets (title only, title and one snippet, title and two snippets, and title and four snippets). They found that while participants preferred longer snippets, their identification of relevant documents was similar across the four layouts, with participants clicking on relevant results with longer summaries and on those that were non-relevant. [41]'s study revealed that longer snippets increased participants' search time and were not as effective for mobile users as they were for desktop users, while the study by [3] indicated that snippets enriched with metadata from corresponding webpages captured users' attention.

A third line of research explored users' reactions to the linguistic features of summaries. [42] found that participants were more likely to identify relevant documents when using query-biased summaries (i.e., summaries generated with respect to the query rather than by extracting representative sentences from a document). Query-based summaries were also preferred on mobile devices [43]. A fourth line of research focused on the readability of SERPs, revealing that poor readability affects users' judgement of relevance and click behaviors [9, 10]. These research efforts involved adult users.

2.3 Young Users' Interaction with SEs

Young users engage in complex web activities as early as six years of age [44]. Studies showed that children (aged 11–13) experienced difficulties with formulating search queries in SEs and hardly found documents relevant to their queries [23]. In using Google, young children (aged 7, 9, and 11) struggled with constructing effective search queries [e.g., 18, 14, 45, 46]. Query reformulation is a consistent problem among young users. A child aged 13, for example, reformulated a search query in Google nine times in order to find relevant information on a self-selected search task to no avail [17]. While query suggestions or auto-complete features in SEs have been designed to scaffold users' selection of search terms and phrases, studies revealed inconclusive results about the use of these features. For example, [18] found that young children did not pay attention to the auto-complete feature while typing their search queries in Google, whereas older children made effective use of this feature [20].

2.4 Eye-Tracking Studies

Few eye-tracking studies have involved young users (for a review of eye-tracking studies, see [47, 48]). [13] examined children's behavior on web search results, concluding that children in 5th and 7th grade fixated their eyes on the bolded keywords in snippets, whereas those in the 9th - and 11th -grades read each individual search result. [14]'s eye-tracking study focused on young children's (average age 9–10 years) information behavior and perception of interface elements on SERPs in Google and a German search engine designed for children. They found that children paid more attention and were more attracted to visual representations (thumbnails of media) than textual summaries. [11] found differences between children's eye fixations on search results on SERPs. Children aged 11 fixated 25% less frequently on the Google SERPs they visited per search query than did children aged 13. [16] eye-tracking study concluded that nearly 17% of the children (aged 12–13) only looked at the title of the search result, 50% looked at the titles and snippets but occasionally viewed URLs, and 33% looked almost always at the three components (title, URL, and snippet). Ability to decode words and understand lexical representations [49] and reading comprehension combined with cognitive frames influence young users' task performance [30]. None of these reviewed studies examined children's understanding of the components of search results on SERPs.

2.5 SE Ranking

The ranking position of results on SERPs and their perceived relevancy affect users' click selection decisions, regardless of age [50]. An early study of children's (aged 12–13) interaction with SEs showed that they did not go beyond the first page of search results, clicked on the top search results above the fold, and hardly examined other results on a page [23]. This behavior has been found to be consistent over different search engines and over time. For example, on Google, studies revealed that children (aged 7, 9, and 11) clicked on the top ranked results and stopped at the sixth-ranked result on a SERP [18, 51, 52]. [15] reported that children's click behavior on Google search results was more frequent on the first- and second-ranked results and that this behavior varied by age. Children aged 11, for example, clicked more frequently on first- and second-ranked results, compared to children aged 13 whose clicking ranged from the first- to the sixth-ranked result. [12] found that children (aged 6–13) considered the top three-ranked results as the most relevant to their search queries. Reversing the ranking order of search results on a SERP did not affect users' selection of top-ranked results [6, 7, 53].

In sum, numerous studies have examined the design and representation of SERPs with adult users. Work that investigated young users' interaction with SERPs has mainly focused on ages 10–14 years. While [16] investigated the effect of young users' prior knowledge of the web on their viewing and selection of search results on SERPs, it ignored their conceptual understandings of the structural components of these results. While one study found that the visual representation in a search result on a SERPs is more attractive to young users than textual information, it did not examine the users' conceptual understanding of the structural components and design representation of results. To the best of our knowledge, no study has investigated teens' conceptual understanding of SEs functionality and, specifically the design representation of the components of search results on SERPs. Thus, in this study, we addressed the following research questions:

RQ1. What conceptual understanding do teens have of SERPs in relation to: (a) how SEs find search results; (b) how SEs generate summaries/snippets of search results; c) how SEs structure or design the components of search results; and (d) how SEs rank search results?

RQ2: What Are the Differences Between Teens' Conceptual Understanding of the Design of the Structural Components of Search Results on SERPs and the Google designer's Conceptual Model or Design of These Components?

RQ3: What do teens learn in school about SEs?

RQ4: What do teens suggest for improving the design of Google?

3 Method

This study is exploratory and employed the survey method to collect data from teens. Exploratory research is often conducted in new areas of inquiry where researchers seek to “scope out the magnitude or extent of a particular phenomenon, problem, or behavior” ([54], p. 5); or to tackle a new problem or behavior on which little or no previous research exists. This exploratory study allowed us to develop an initial understanding of the nature of teens' conceptual understandings of SEs and various aspects of SERPs. While exploratory research may not lead to a highly accurate understanding of this topic, or to generalizing the findings, it is “worthwhile and serves as a useful precursor to more in-depth research.” ([54], p. 6).

3.1 Instrument

The initial survey instrument was tested with six teen participants in multiple iterations, based on which modifications were made. The final instrument included nine open- or close-ended questions. The questions pertaining to the present study include: demographics, prior experience with the internet and SEs, use of SEs, specific aspects of SERPs (including how an SE finds, generates summaries of, and ranks search results), identification of the structural components of snippets, learning in school about the internet and SEs, and suggestions for improving SEs.

3.2 Search Results on SERP

We extracted a search result from Google consisting of four components (title, URL, snippet, and a video thumbnail, Fig. 1).



Fig. 1. Search result shown to teens in the survey

3.3 Participants

We contacted 110 parents among whom 38 had children aged 15–17 attending high schools. We sought participants up to age 18 but no responses were obtained from that age group. Typically, in the US, high school begins at age 15 and ends between ages 17–18 and the teens in this study fell within this age range. The majority (83%) attended schools in different districts located in four different geographic areas (names are kept confidential). Of the 38 who took the survey, 22 provided completed responses.

3.4 Procedures

The survey was implemented in Qualtrics. We collected data between February and April 2019. Following our university Institutional Review Boards (IRBs) of the study, we contacted our personal networks, regional and state professional association listservs, researchers' universities, colleges' and departments' listservs, and used word-of-mouth to identify parents with youth in the desired age range. As minors, teens (aged 15–17) must obtain parental consent and provide their own assent to participate in this study. We sent an email invitation to the parents who expressed willingness to allow their teens to participate. This email described the purposes of the study and contained the survey URL. Once the URL is clicked, the parental consent form appears in Qualtrics and a parent has the option to agree (clicking Yes) or disagree (clicking No) to their teen's participation. By clicking Yes, the teen's consent form is displayed describing the study and providing instructions on completing the survey. Teens have the option to click Yes or No. Upon clicking Yes, the survey questions will be displayed one screen at a time. Teens could opt out of the survey at any time without penalty. We followed up twice with the teens' parents. Our recruiting was limited to the U.S. and had no exclusion criteria.

4 Data Analysis

We analyzed the quantitative data using descriptive statistics, facilitated by Microsoft Excel. We analyzed the qualitative data collected by the open-ended questions using the qualitative content analysis method [55], facilitated by MAXQDA 2018 (VERBI Software GmbH). We read all the responses and coded them based on the research questions. New themes were allowed to emerge from the data. The codes were then compared and contrasted, and, thereafter, organized into categories. We validated the codes by double-checking the codes against the participants' responses.

In order to identify the extent to which teens' understanding of the structural components of a search result (Fig. 1) matches with the Google designer's conceptual model or interface design of these components, we assigned a score of "1" to a correct answer and of "0" to an incorrect answer for each of the four components (Fig. 1). We calculated the percentage of correct answers a teen provided on the four components. For example, a teen who gave a correct answer to all four components received a score of 4 or ($S = 4$), resulting in a 100% match with the designer's model or interface design of these components. Conversely, a teen who had no correct answers on any of the components received ($S = 0$), resulting in a total mismatch with the designer's model.

5 Results

5.1 Participant Demographics

A total of 22 high school teens (7 females and 15 males) from three states completed the survey (one from Florida, two from Washington, and 19 from Tennessee). Their ages ranged from 15 to 17 years old, with 12 being 15, three being 16 and seven being 17 (Mean = 15.8; SD = 0.92). Their grades spanned from high school freshmen to sophomores. The teens from Tennessee were from four different school districts in different geographic areas and attended different schools within a district (Names are kept confidential).

5.2 Experience and Use of SEs

All teens used the internet to find information on a daily basis, with 12 reporting doing so more than 6 times a day, five 4–6 times a day, and five 2–4 times a day. All except one teen (21, 95.5%) used the internet without parents' help. The majority of the teens considered themselves very experienced (14; 63.6%) or moderately experienced (6; 27.3%) or experienced (2; 9.9%).

Google is the most favored SE among all teens, with 77% indicating using Google to find information for research and other classroom assignments.

5.3 RQ1a: Teens' Conceptual Understanding of How SEs Find Search Results

Nearly 41% of teens (9, 40.9%) indicated that they do not know how SEs find results. Among the remaining teens ($n = 13$), 9 (69.2%) pointed out that SEs pull results based on keyword match. For example, one teen commented: "It uses keywords and compiles all the websites that contain those keywords." Two among the nine teens (22%) demonstrated a bit more sophisticated understanding by mentioning additional search mechanisms. One teen mentioned, "location of the computer" and "recent search history," but did not elaborate on either mechanism. The other teen pointed out that SEs look for similar topics. The teen commented: "[A web search engine] combs various sources for keywords and phrases as well as websites which focus on similar topics." One teen did not mention search mechanisms but commented on the feature of search results. The teen indicated: "I guess it searches a data base and brings up the most relevant result." The other teen did not mention keyword match, but touched upon on what SEs examine to pull up results, commenting that SEs "scan[s] the titles and the website to generate a page of websites for you to decide on."

Three teens had misconceptions. One teen mentioned, "It takes years of programming into account and comes up with a result." The second teen wrote that SEs find results based on, "Research off of other sites or news articles or professionals." The third teen perceived that the search results "are created based on the degree of importance and relevance of information on a webpage."

5.4 RQ1b: Teens' Conceptual Understanding of How SEs Generate Summaries of Search Results

About 30% of the teens (7, 31.8%) could not articulate how SEs create the summaries or snippets. Among the remaining teens, eight (53.3%) thought that the summary was constructed based on certain parts of webpages, including (the numbers in the parentheses refer to the number of teens; one teen could mention multiple points): “lines directly surrounding the keywords” (2); “first paragraph, first few sentences, or first few lines of text of the webpage” (3); “a paragraph or sentence with most of the keywords you searched for” (2); and “sentences with the searched keywords” (2).

Two teens were not able to go into this detail. They only commented that the summary is created based on keywords, specifically “from what you searched up and what they found in the article,” “matches to what you searched for,” and “based off of keywords in one’s search.” Four teens described features of summaries, unable to speculate how they were generated. Among them, one teen described a summary as “a paragraph or so that includes the keywords for which you searched.” One teen mentioned that a summary “highlights keywords that are [in] the original search.” The other teen noted that a summary shows “the most relevant piece of information.” One other teen thought it was the retrieved websites that created the summary, saying, “I think the website creators make the snippets.”

5.5 RQ1c: Teens' Conceptual Understanding of the Design of the Structural Components of SE Search Results on SERPs

Teens described the numbered components (items) in Fig. 1 in the following ways:

Item 1. Two teens (9%) reported not knowing how to name this item. Fifteen teens (75%) properly described Item 1 as *title*, *headline*, or *heading*. The remaining five teens (25%) provided non-optimal descriptions (i.e., *hyperlink*, *snippet*), or simply described the content in Item 1: “what the game is called.”

Item 2. One teen (4.5%) reported not knowing how to name this item. Twenty teens (95.2%) properly described Item 2 as a *link*, *URL*, *website*, or an *address*. The remaining one teen labeled it wrongly as *title*.

Item 3. Two teens (9%) reported not knowing how to name this item. Thirteen teens (65%) properly indicated Item 3 as *summary* and *description*. The remaining seven teens (35%) described it incorrectly as *the name of the game*, *an introduction*, and a *Star Wars movie*.

Item 4. Two teens (9%) reported not knowing how to name this item. Fourteen teens (70%) properly described Item 4 as a *video*. However, only four of them were able to speculate why it is part of the snippet. They noted, for example, it is *the main video of the page* and it is *from a video website*. The remaining six teens described it incorrectly as *image*, *picture*, or *thumbnail*.

5.6 RQ1d: Teens' Conceptual Understanding of How SEs Rank Search Results on SERPs

Among the 22 teens, three (13.6%) were not able to speculate on how SEs rank search results. The remaining teens (19; 86.4%) mentioned four criteria by which SEs do the ranking, as shown next. One teen could mention multiple criteria.

Popularity. The most widely held criterion (13; 68.4%) is *popularity*, referring to how many people have clicked, chosen, or used that result. An example is: *I believe the search engine orders the results based on the popularity of the website. In other words, I believe it is based on how many clicks it usually gets by users.*

Relevance. Nine teens (47.4%) mentioned *relevance* based on keywords, referring to whether or not a result contains keywords, all keywords in the query, the highest number of keywords, most of the number of keywords, a number of keywords, or keywords that are in the same order as they appear in search queries. For example, one teen mentioned, *whichever mentions the keywords the most or seems most relevant [ranks higher].*

Fee. Three teens (15.8%) indicated that SEs rank results by fee. An example is: *Some websites pay to have their site show first, others are popularly visited.*

Publishers. One teen thought that results are ranked based on *features of information providers* and that results that came from *large publishers* are ranked higher. The teen commented:

If it's the most used, biggest publisher, or how much a company pays the search engine workers to make their result the first.

5.7 RQ2: Differences between Teens' Conceptual Understanding of the Design of the Structural Components of Search Results on SERPs and the Google Designer's Conceptual Model (Interface Design) of these Components

Six teens (27%) correctly named/described all four components of the extracted Google search result (Fig. 1; $S = 4$), matching 100% with the designer's model; 7 teens (~32%) correctly named/described three components ($S = 3$), matching 75% with the designer's model; 5 teens (22%) correctly named/described two components ($S = 2$), matching

Table 1. Teens' identification of components of search results versus Google design

No. of Teens (N = 22)	Correct identification of components of search result (S = 4 = 100%)	Match with designer's model/interface design (S = 4; %)
6	4	100
7	3	75
5	2	50
3	1	25
1	0	0

50% with the designer’s model; 3 teens correctly named/described one component (S = 1), matching 25% with the designer’s model; and one teen had incorrect answers to all four components of the search result (S = 0), resulting in a none-match with the designer’s model (Table 1).

5.8 RQ3: Teens’ Learning in School About the Internet and SEs

Two of the 22 teens mentioned a feature related to SE searching skills (Table 2). Over half of teens learned how to assess source reliability (54.5%) and to ensure safety in using the internet (18.2%). Surprisingly, 6 (27.3%) teens indicated learning nothing about the internet and SEs. Note that some teens reported on more than one area of learning.

Table 2. Teens’ learning in school about SEs

Area of learning	No. of Teens (N = 22)	Percent
How to cite source	1	4.5
Should not plagiarize	1	4.5
Nothing	6	27.3
Safety	4	18.2
Be careful about source reliability	12	54.5
Search skills	2	9.1

5.9 RQ3: Teens’ Suggestions for Improving Google Design

Nine teens (9, 40.9%) were not able to provide any suggestions for improving SEs. The remaining teens expressed desire for SEs to improve on three aspects: (1) SERPs, (2) search and retrieval functions, and (3) privacy. Table 3 summarizes the results.

SERPs. All the remaining 13 teens wanted to see improvement on search results. They wished to be exposed to fewer or no advertisements (particularly fraudulent advertisements), be able to filter results based on location and to filter out non-credible sources, and be able to sort sources by credibility and reliability. Additionally, they wished to see a rating system indicating the level of helpfulness of a result in relation to a search. One teen also expressed desire not to highlight the top result. The teen may be referring to the featured snippet that provides an answer to a question. Not knowing the difference between the “organic” and highlighted or boxed snippet, the teen commented:

“There is often a “highlighted result” that appears at the top of the page with large font, a longer summary than other results, and an accompanying image, and then this result ends up being the first in the following list of regular results anyway. I don’t think it’s necessary to highlight the top result if it’s also going

to be displayed first in the list. It usually distracts me from more helpful results because it takes up so much of the page that I click on it automatically, even if it clearly doesn't contain the information I'm looking for."

Table 3. Teens' suggestions for improving Google design

Aspect	Specific suggestions	No. of teens (N = 22; percent)
SERPs	<p><i>Highlighting top search result</i></p> <ul style="list-style-type: none"> - Unnecessary to highlight top search result <p><i>Ads</i></p> <ul style="list-style-type: none"> - Limit ads.; fewer ads.; remove fraudulent ads, no ads <p><i>Filtering</i></p> <ul style="list-style-type: none"> - Filter out non-credible sources - Need a location filter <p><i>Sorting</i></p> <ul style="list-style-type: none"> - A known fact to be the first source of information - More credible sources at the top of search results - Sort by reliability <p><i>Displaying</i></p> <ul style="list-style-type: none"> - A rating system to indicate whether a suggestion is helpful - Not highlight the top result 	13 (100%)
Search and retrieval functions	<p><i>Find best results</i></p> <ul style="list-style-type: none"> - Use AI to find the best results for the search - Have the keywords work better <p><i>Specific functions</i></p> <ul style="list-style-type: none"> - In-text search - To be able to use + or – signs - To be able to pick up on keywords - To be able to search not based on previous search history 	8 (61.5%)
Privacy	<ul style="list-style-type: none"> - Stop keeping my information - Stop selling information to commercial entities 	2 (15.4%)

Search and Retrieval Function. Teens expressed a desire to find better, more relevant search results, presumably through Artificial Intelligence (AI) technologies and keyword search technologies. They also suggested specific functions, including in-text search, supporting + and – signs, freedom in choosing keywords, and search not shadowed by prior search history.

Privacy. Two teens also expressed a desire to see tighter protection of their personal information from SEs. One wished that SEs not keep or sell their personal information.

6 Discussion

Google is the favorite SE for teens in this study. We found that over half of teens (54%) did not know how SEs find search results and 13% had misconceptions to that effect. Although this is a high percentage, it is not surprising given that teens were not exposed to formal learning about this “backend” process in school. Teens who mentioned that SEs use a variety of ways to find results (i.e., keyword match in a page, location of the computer, or recent search history) may have incidentally learned about these processes through informal channels, such as peer, family members, or other media (incidental learning) [56]; or through trial-and-error (experiential learning) [57].

The study findings showed that nearly 54% of the teens recognized that the summary is generated based on certain parts of webpages, but provided simplistic explanations to that end (i.e., based on keywords of one’s search; lines surrounding the keywords; sentences with the search keywords, and a paragraph or sentence with most of the keywords you searched for). Bolded keywords in snippets provide cues as to a match between a user’s search query and retrieved results; thus, providing some transparency to the user. Nonetheless, one-third of the teens could not articulate at all how SEs generate the summaries or provide examples illustrating their understanding of this process. This deficiency is attributed to a minimal or lack of exposure to effective instruction about SEs in school.

While all teens identified the URL correctly, the majority of them had limited understanding of one or more components of the search result presented to them (Title, Snippet, and video). The gap we found between teens’ conceptual understanding of the structural components of the search result and Google designers’ conceptual model (interface design) of these components challenges assumptions of the self-explanatory nature or transparency of human-centered design. As [1] notes, a gap between the designer’s conceptual model of a system and that of the user could create confusion, errors, and difficulties in using a system. This problem can be further exacerbated by absence of or very limited instruction in school about SEs beyond safety and credibility assessment.

Teens are aware that paid ads are ranked first on a SERP. The majority of them are also cognizant of two of the several factors SEs use in ranking results aside from ads, popularity and relevance, but their explanations were not optimal. Three teens, however, did not know how result ranking works, and three other teens had misconceptions about it. This is expected as teens’ understanding of SERPs is mostly perceptual and founded on “incidental” or “experiential learnings” [56].

The finding that teens attended schools that provided minimal exposure to searching skills or no formal instruction about SEs seems to be consistent across different schools in Tennessee. In a study of children's (aged 11 to 13) interaction with Google, [15] found that the majority of the children learned about Google ranking from "peers," "family members," or "somewhere" and were unable to recall the learning source.

Teens' suggestions for improving Google emphasized filtering non-credible results, sorting SERPs by credibility and reliability, and providing a rating system of result usefulness based on which to rank SERPs. Apparently, judging the reliability and credibility of SERPs is a tedious task for teens. This is especially true given that the majority of schools that the teens attended focus on these two evaluation criteria in teaching about SEs. In light of today's abundant fake information on the internet, including fake URLs, a credibility filter associated with the usefulness or relevancy of SERPs vis-à-vis search queries could reduce teens' cognitive load in judging SERPs while supporting their emotional experience during the interaction. Additionally, Advertisements appearing at the top of a SERP seem to be frustrating and distracting for a few teens. Advertisements are a revenue generator for SE companies. Nonetheless, offering an advertisement filter could reduce or eliminate teens' negative affect and provide a more positive experience.

It seems that teens are not satisfied with the nature or retrieval of Google SERPs, as evident in the comments, "find best results" and "have the keywords work better." One teen suggested that SEs use AI to improve search results, implying desire to see improvement in search results. The "in-text search" suggestion may imply that teens want to be able to search by keyword within web pages. This search feature is available in web browsers using the (CTRL F) keys. Apparently, the teens who mentioned this were not aware of the Find function in the browsers. The operators (+ and -) to which one teen referred are already supported in Google, although not explicitly. Additionally, the suggestion "not use search history" to find information for a search query indicates that personalization is another feature that seems to frustrate some teens. Google designers should reconsider the personalization feature and possibly make it optional. Nonetheless, this functionality may be effective for another teen population. Therefore, this feature should be explored with teens in future studies to identify reasons for its non-optimal liking.

Privacy is of concern to the two teens who asked that SEs "stop keeping [my] information" and "stop selling information to commercial entities." These comments clearly reflect on those teens' awareness of SEs' practices in terms of sharing one's personal information with other companies. How to use browser functions (e.g., Incognito) to protect one's personal or behavioral information needs to be conveyed to the teens in schools.

6.1 Limitations

This study is exploratory, and the findings are not generalizable. The data were self-reported and tended to be subjective and possibly prone to inaccuracy. However, it sheds light on a less explored area, teens' conceptual understanding of SERPs, and generates some interesting and important hypotheses for more in-depth research.

6.2 Implications

This study revealed that teens' conceptual understanding of various aspects of SERPs is more perceptual than conceptual and is mostly guided by "incidental" and "experiential learnings" rather than systematic instruction in school. The gap between teens' understanding of the components of search results and Google designers' conceptual model (interface design) of the components is critical. The findings have practical and theoretical implications.

Practical. We urge information practitioners in schools to provide innovative pedagogical SE literacy programs that go beyond safety and credibility assessment to include various retrieval aspects of SERPs. Exposure to systemic instruction is essential for adjusting teens' conceptual understanding of specific aspects of SE functionality to scaffold their thinking and learning and prepare them for successful academic work as they transition to college.

The significant gap between teens' conceptual understanding of the structural components of a Google search result and the designer's model of these components is contrary to the designer's belief that *one-size-fits-all*. Not all teens are able to decipher, understand, name, or identify the purpose of these components. Thus, we urge designers to consider a design with better affordances and signifiers [1]. For example, using hover over text to present details about each component could make these components more self-explanatory and transparent [38].

Theoretical. The findings provided initial insights into the *nature of conceptual understanding* teens hold about SERPs and the nature of their learning in school about SEs. These findings call for new theoretical directions in future studies that integrate teens' interaction behavior in using SEs alongside their conceptions of these tools so that we develop a more coherent, nuanced understanding of their needs, and develop design solutions that meet those needs.

7 Conclusion

This study explored the nature of teens' conceptual understanding of web search engines (SEs), emphasizing key aspects of Google SERPs. Teens' understanding of SERPs is more perceptual than conceptual and is mostly founded on "incidental" and "experiential learnings." Teens possessed limited understanding, inaccurate understanding, or no understanding of key aspects of SERPs. This is attributed to two main factors, minimal or lack of exposure to SE information literacy in school beyond assessing credibility and reliability of search results, and to limited transparency in the design and representation of SERPs, particularly the components of search results. Exploring teens' conceptual understanding of SEs and, specifically SERPs, is a worthwhile area of study to investigate more in-depth in future research. Detecting teens' effective and efficient interaction behavior with Google alongside conceptual understanding of SERPs will provide a new lens for validating whether conceptual understanding has an effect on teens' task performance and overall experience with the search engine.

In this study, we collected data using the survey approach. Incorporating a mixed research design will heighten our understanding of the validity of teens' claimed experiences with SEs vis-à-vis their interaction behavior and performance in context. Future research should investigate the level of information literacy programs provided in school for various aspects of SEs not only from teens' perspectives, but also from those of school librarians in order to gauge an analysis and evaluation of these programs and correlate with teens' conceptual understandings, interaction behaviors, performance, and emotional experiences.

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