

Searching for Engagement: Child Engagement and Search Engine Result Pages

Benjamin Bettencourt
Boise State University
Boise, Idaho, USA
benbettencourt@u.boisestate.edu

Arif Ahmed
Boise State University
Boise, Idaho, USA
arifahmed@u.boisestate.edu

Nic Way
Boise State University
Boise, Idaho, USA
nicway@u.boisestate.edu

Casey Kennington
Boise State University
Boise, Idaho, USA
caseykennington@boisestate.edu

Katherine Landau Wright
Boise State University
Boise, Idaho, USA
katherinewright@boisestate.edu

Jerry Fails
Boise State University
Boise, Idaho, USA
jerryfails@boisestate.edu

ABSTRACT

In this paper, we explore how children engage with search engine result pages (**SERP**) generated by a popular search API in response to their online inquiries. We do so to further understand children navigation behaviour. To accomplish this goal, we examine search logs produced as a result of children (ages 6 to 12), using metrics commonly used to operationalize engagement, including: position of clicks, time spent hovering, and the sequence of navigation on a SERP. We also investigate the potential connection between the text complexity of SERP snippets and engagement. Our findings verify that children engage more frequently with SERP results in higher ranking positions, but that engagement does not decrease linearly as children navigate to lower ranking positions. They also reveal that children generally spend more time hovering on snippets with more complex readability levels (i.e., harder to read) than snippets on the lower end of the readability spectrum.

CCS CONCEPTS

• **Social and professional topics** → **Children**; • **Information systems** → *Web searching and information discovery*; Search interfaces.

KEYWORDS

Engagement, Web Search, Children, Search Engine Result Pages

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1 INTRODUCTION

With the proliferation of internet capable media devices in the home and in educational institutions, children have become regular users

of search engines (**SE**) to meet their information needs. Trends found in the U.S. indicate that by age 8 roughly two-thirds of all children will turn to the internet, and SEs, on a daily basis to resolve information tasks [8]. Despite this increase in use, research findings reveal that mainstream Search Engine Result Pages **SERPs** are not geared towards serving child searchers [7, 10, 16]. In fact, Allen et al. [2] found that children felt that the results presented on mainstream SERPs were not relevant to them. Doherty et al. [6], O'Brien et al. [17], and Allen et al. [2] identified how crucial engagement with SERPs are when it comes to effective searching. However, studies on child engagement with SERPs are scarce [7, 16], despite the presence of studies highlighting the importance of engagement with SERPs relating to adults [17]. Given the scope of this problem encompasses children's behaviour on a SE and their ability to interact with relevant documents on a SERP, children's behavior should be understood to guide researchers in how to build better SE. As a stepping stone to address the struggles children experience and to make SERPs more effective, we need to better understand how children interact and engage with the SERPs through the concept of user engagement (**UE**).

Engagement is a complex and multifaceted concept that encapsulates the driving force behind someone's motivation, tenacity, and/or willingness to complete a task [14, 17]. Due to this complexity, there have been multiple perspectives for capturing engagement, we focus on the engagement efforts that are put into resolving a child user's information needs for our concept of UE [14]. With this in mind the purpose of this paper is to explore and examine how children engage with SERPs. Our driving question for this paper (**RQ**) is: How do children engage with a Search Engine Result Page (SERP)? To help answer this question and given that Zhuang et al. [18] and Huang et al. [13] have shown that metrics like **Clicks** and **Hovers** can be effective indicators of engagement, we will adopt these as a proxy of engagement for this paper. To better understand what the clicks and hovers mean, and due to prior studies showing that children tend to navigate SERPs linearly, engaging with higher-ranked results more frequently than that of middle to lower ranked results [9, 12], as a part of our clicks and hover analysis we also investigate the sequence of SERP navigation that children undertake.

Capturing engagement and SERP navigation with clicks and hovers alone provides an entry point, however, we need to further understand why children choose to engage with various SERP

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results. To further understand that why, we investigate an additional important dimension factor, **readability**. Guthrie et al. [11] found that young students were more engaged with texts they felt they could comprehend. Bilal et al. [3] found that the grade level or age of child users affects their eye fixations on SERP results; eye fixations were considered a proxy for engagement. Furthermore, Bilal et al. [4] measured and compared the readability of text on Google and Bing SERPs produced from queries formed by children, Grades 6-8. This study found that when children could not comprehend the results on SERPs it was an obstacle to child searchers. In this paper we will measure text readability of results to examine how it affects child engagement.

In line with our RQ, in this work-in-progress we provide an overview of children's engagement with SERPs using clicks and hovers, investigate how those relate that to readability, and investigate if readability affects the path they took while navigating the SERP.

2 ANALYSIS SETUP

In this section we first describe the dataset and metrics used to investigate children's engagement with a SERP. Then, we describe the experiment we conducted to answer our research question.

2.1 Data

We rely on the search logs produced by CSE, a children's search engine [name blind for review] from May 2019 to April 2021. During this time, children aged 6-12 worked in informal education settings to complete inquiry assignments (e.g., finding information on the largest dinosaur or on the state bird). Retrieval, ranking, and SERP generation for CSE is powered by the Bing Search API with safe search on¹. The resulting data includes 353 unique user sessions (which we use as a proxy for the number of child participants) and 1029 queries.

2.2 Metrics

Works related to UE and SERPs (but not with children) have measured engagement within a SERP, using subjective (self-reports, questionnaires, etc.) [17] and objective (clicks, queries, etc.) [17, 18] measurements of engagement. To that end, we undertook steps into the relatively-unexplored area of child UE with SERPs by quantifying engagement using the behavioral features: **clicks** $C \in \{yes, no\}$ and **time spent hovering on a search result** (T_{hover}) [13, 18]. We define T_{hover} as a cursor hovering over a search result on the SERP. We filter out any hovers that are less than one second long to eliminate accidental hovers and to reduce the impact of outliers we filtered out hovers that lasted for longer than ninety seconds. We define a click as when a user clicks on a search result from the SERP results $S_{results} = [r_1, r_2, \dots, r_n]$, where $n \in [1, 10]$ and where n represents the position of the result being clicked, i.e. $n=1$ means the result clicked was the first(top) result r_1 on the SERP. We refer to the period of time between a user starting to hover over a result and subsequently clicking on that result, without leaving that result (i.e., no longer hovering over the result) as a Time Hovering Before Click (T_{HBC}). When we refer to the clicks occurring in these conditions, we refer to them as Hover Before Click (C_H). The

period of time between a user hovering over a result then moving the mouse away from that result, is called Time Hovering Before Navigation (T_{HBN}), and the occurrences of these hovers as Hovers Before Navigation (H_N). To assess the frequency of clicks on a result relative to the number of times it is hovered over, we also calculate a Click/Hover Ratio (CHR) by the formula: $CHR = C_H / (C_H + H_N)$. Finally, we capture the amount of time a user spends between queries or ends their search task.

To measure SERP navigation sequence we used a Kendall τ 's rank correlation. The correlation coefficient indicates the degree of linearity where +1 indicates complete linear navigation (e.g. hovering over r_1, r_2, r_3 or r_1, r_3, r_6) and -1 indicates non-linear navigation (e.g. hovering over r_1, r_3, r_2 or r_1, r_6, r_3).

Text readability is interpreted as how easily and quickly a reader can comprehend the text document [5]. We measured the text difficulty or complexity of SERP snippet text using the Spache-Allen (SA) [1] readability formula, which can effectively capture the text complexity of web resources for children. Each of the search result r_i consists of a title t_i and snippet s_i (description of text). We measured the text complexity R_{title} from t_i and $R_{snippet}$ from s_i using the SA formula. To get an overall text complexity of each r_i , we concatenate the t_i and s_i and denote it as e_i (element). Then, we compute the text complexity $R_{element}$ from e_i . After evaluating the text complexity of search results $R \in \{R_{title}, R_{snippet}, R_{element}\}$, we calculated the correlation between R and engagement metrics using Pearson correlations.

2.3 Methods of Analysis

In order to explore engagement, we conducted several experiments using the data and metrics introduced in Sections 2.1 and 2.2.

2.3.1 Tests for Traditional Metrics of Engagement. We used clicks to examine children's behaviors while visiting the search results r_i on the SERP. We analyzed user clicks and hovers to understand the sequence or pattern they follow while visiting r_i on the SERP. To evaluate the sequence of r_i visit for linearity, we calculated the Kendall τ 's correlation between the sequence of r_i a user clicks for a query and its sorted values.

We calculated a similar rank correlation for the hover sequence of r_i for each queries. We also tried to learn the position or rank i of the search result r_i they mostly click. As a supplement to the click analysis, we utilized hovers as another signal of users' engagement. We analyzed the T_{hover} to understand users' click behavior and position bias in SERPs. In that case, we investigated T_{hover} for both clicked and non-clicked results r_i . For further in-depth analysis, we randomly selected some queries where the users clicked on bottom search results r_i , where $i > 5$. We calculated a CHR for search results r_i to evaluate trends in click frequency versus hover frequency.

2.3.2 Tests for Readability. In order to understand how readability affects child engagement, we looked at the readability of results and their relationship to clicks and hovers. We hypothesized that children would: (1) click on results r_i they could more readily read, i.e. search results that had readability scores closer to the child's reading level; and (2) hover longer on search results that had lower readability scores. To test our hypotheses, we investigated how

¹<https://www.microsoft.com/en-us/bing/apis/bing-web-search-api>

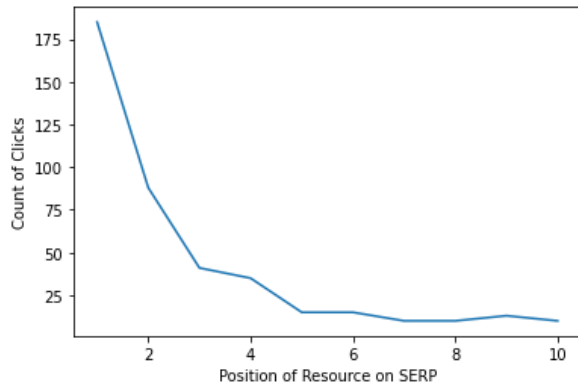


Figure 1: No of Clicks vs Position on SERP

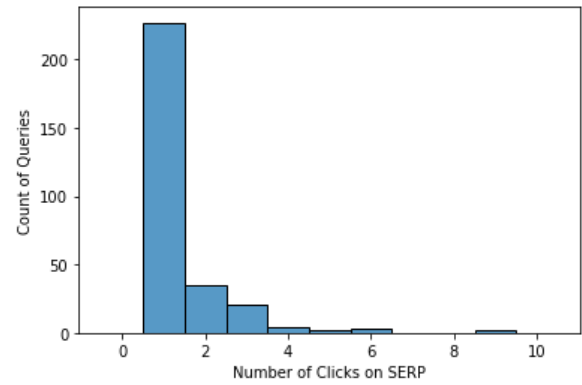


Figure 2: No of Queries Vs No of Clicks on SERP

readability scores R of r_i correlated with engagement metrics (clicks, hover time).

We filtered queries based on whether a user activity matched our click or hover time criteria (C_{yes} or $1s < T_{hover} < 90s$). This filter ensures we only study the engaged r_i 's. We computed the statistics (mean, max, min, standard deviation, and inter-quartiles) of R_{title} , $R_{snippet}$, and $R_{element}$ for both clicked and non-clicked search results to compare the readability level of engaged and non-engaged r_i 's. Additionally, we calculated the Pearson correlations between text complexity of t_i , s_i , and e_i with hover times which we represent as $Corr(R, T_{hover})$. The correlation coefficient informs how text complexity affected users' level of engagement (e.g. for a negative coefficient value, if there is an increase in text-complexity R then there will be a decrease in T_{hover}). We also calculated the correlation $Corr(R, C)$ between readability scores (R) and click (C). Since "Click" on search results directly signals engagement with those particular search results, we selected only the clicked search results (exclude hovering results) and conducted the same correlation analysis we conducted for hovers.

Since our users were in grades 1-6, we surmised that ideally they should be able to comfortably read any text with a readability score for those grade levels. We posit that children will spend more time comprehending texts beyond their reading level (grades 7-12). So, we calculated $Corr(R, T_{hover})$ to know users' engagement behavior. Besides, we also capture their behavior using clicks and hovers when they read text within their reading level and beyond their reading level.

2.3.3 Tests for Navigation. Along with click sequences, we captured the change in the text complexity when a user perform clicks on r_i . We also examined the hover sequences to check whether a user hovers longer over a r_i snippet text with greater text difficulty (as identified by a higher readability score) or whether the opposite was true (they hovered longer over "easier" texts).

3 RESULTS AND DISCUSSION

In this section, we report the evaluation results for the traditional metrics of engagement as well as the analysis of readability described above.

3.1 Traditional metrics of engagement

As we examined C we could see the number of C for each r_i (as illustrated in Figure 1). We were able to see r_1 gains much more attention from users in the form of clicks than r_i that are ranked lower. 82% of clicks were within the first four ($r_1 - r_4$) search results. This was observation of clicking on the first four results was understandable as in the SE we used, CSE, each results were fairly large and beyond 4 results often would require scrolling (based on screen resolutions used).

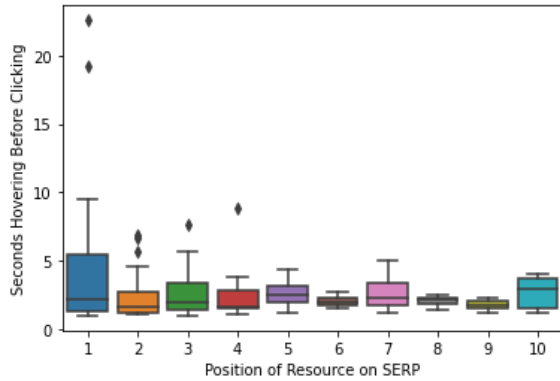
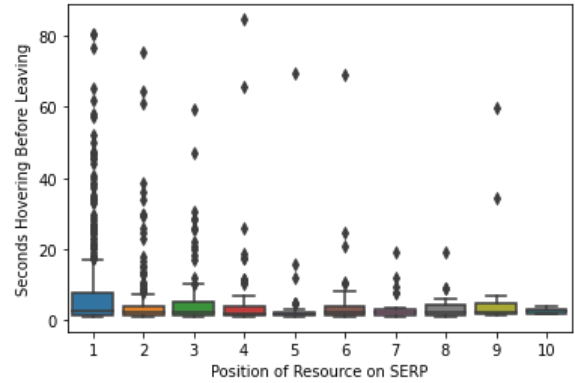
To verify that the results of primarily clicking on the top four results were not caused by users clicking on the same r_i multiple time in the same query we counted the number of C in each query. For queries where users clicked on at least 1 search result, we found users did not click more than a single r_i most of the time. Figure 2 illustrates that most users clicked on only one result per query. This could mean that either the single result the user clicked on was sufficient to satisfy the information need or the user was so frustrated that they gave up on their query. This pattern of behaviour results in most results on the SERP getting very few interactions. While children generally clicked on only one result, there were 42 (of 353) users that clicked on several r_i s where the maximum number of clicks made for a query was six.

In order to more clearly understand user behaviors, we analyzed the sequence of hovering search results and the sequence of clicking search results to discover users' general sequence of navigating the search results, $S_{results}$. We computed a Kendall τ 's correlation of +0.77 (mean) for hover sequence from 353 queries. For the click sequence of search results, we found Kendall τ 's correlation of +0.87 (mean) for 294 queries. These two correlation coefficients show that children visit or navigate search results r_i linearly for both clicks and hovers. The sequential click correlation finding aligns with a previous study that analyzed linearity based on click sequence only [15].

In addition, we examined the frequency of C_H for each r_i to understand the distribution of clicks in our dataset across each r_i . We also identified the T_{HBC} and H_N for each r_i and compared the hover time between clicked results and non-clicked results. Figure 3 and Figure 4 show the distributions of our findings. In general, users hovered longer on results that they ended up not clicking on.

Table 1: Count of C_H and H_N occurrences with mean T_{HBC} and T_{HBN} for each r_i with aggregated data for all r_i in the bottom line

r_i	C_H Count	Mean T_{HBC} (seconds)	H_N Count	Mean T_{HBN} (seconds)	CHR
1	77	3.690	410	8.010	0.158
2	32	2.319	187	5.503	0.146
3	18	2.699	124	5.541	0.126
4	9	2.768	64	6.268	0.123
5	4	2.649	41	4.142	0.089
6	3	2.077	30	6.541	0.091
7	5	2.752	25	3.753	0.167
8	4	2.072	23	3.801	0.148
9	3	1.783	20	7.133	0.130
10	5	2.688	9	2.622	0.357
All r_i	160	3.059	933	6.554	0.146

**Figure 3: Hover then Click****Figure 4: Hover then Navigate Away**

This suggests that if a result requires high effort to comprehend then a child may not click on it.

Table 1 and Figure 1 both indicate that users clicked and hovered longer more frequently on results that were higher-ranked (more towards the top of the result list). These findings in conjunction with the observation of linear navigation by children (discussed briefly in the method and more in the results discussed later), align with prior research by Gwizdka et. al. [12] which documented children’s (ages 11-13) behavior with SERP. In calculating the CHR, we found that children click on results in the middle most positions (r_4 - r_6) at lower frequencies than either the top (r_{1-3}) or bottom (r_{7+}) ranked results. The CHR is helpful here since this trend is not immediately obvious when looking at the other metrics. When looking at C_H and H_N counts alone we see that these metrics dramatically decrease as the r_i increases; however, the rates at which these values decrease is not the same between the two metrics (causing a change in CHR) nor is the change from result to result linear. This prompts questions around why children are more likely to click on a result on the bottom of a SERP. In particular, the CHR for r_{10} is over twice as high as any other r_i . Since our users navigated the SERP linearly, we posit that this means that if a child navigates to the bottom of

a SERP they are desperate to click on a result which explains this high CHR. To help confirm this, we investigated users’ position bias toward bottom ranked r_i ’s. We found some queries where children were navigating search results and clicked on bottom search results. We randomly selected a query where the query term was “row bots” and the children user hovered all the search results except r_2 and clicked on r_{10} only. We found that only the clicked r_{10} had a “robot” word in the title t_{10} . We assume that children intended to search for “robot” but made a spelling mistake while writing the query. Since there were no other results containing robot the child was desperate enough to click on the one result that did.

3.2 Readability

We hypothesized that text readability was a factor that affects children users’ engagement. Our initial results informs us of the text complexity of engaged (clicked or hovered) vs. non-engaged (non-clicked nor hovered) search results r_i . The mean value of R_{title} , $R_{snippet}$, and $R_{element}$ for clicked search results (4.84, 5.37, and 5.05) was lower than non-clicked search results (4.94, 5.52, and 5.28). From hovering search results, the (maximum, minimum) readability score (grade level) of snippet text for clicked and non-clicked search

Table 2: Relationship between Hover time (T_{hover}) and Readability (R)

Correlation between Readability score (R) and Hover time (T_{hover})							
Text readability score		$Corr(R_{title}, T_{hover})$		$Corr(R_{snippet}, T_{hover})$		$Corr(R_{element}, T_{hover})$	
Text Complexity	Grade	C_{yes}	C_{no}	C_{yes}	C_{no}	C_{yes}	C_{no}
Within users' reading level	1-6	0.04	-0.03	0.05	0.02	0.14	-0.05
Beyond users' reading level	7-12	0.26	-0.009	0.60	0.43	0.47	-0.40

Note: Here, $1s < T_{hover} < 90s$, C_{yes} = Clicked, C_{no} = Non-Clicked, and "Corr" is Pearson's (ρ) Correlation

results were (~ 2 , ~ 9) and (~ 1 , ~ 12) respectively. So, most of the children clicked on search results that had an average text complexity of grade-level 5, whereas they did not click on (but hovered) search results that had an average text complexity of grade-level 6.

In analyzing the correlation between C and $R_{snippet}$ we found a correlation score of -0.028. For clicked search results that were hovered for more than 1 second, the correlation between T_{hover} and $R_{snippet}$ was 0.047. There are several possible reasons for such a near-zero correlation score. It might be because our users are from elementary and intermediate levels, and their reading fluency is not the same, which in turn could affect their degree of engagement which would support the work done by Bilal et al. [3].

Moreover, from Table 2 we see how readability scores of clicked search result elements correlate with hover times when r_i 's text's readability is within and beyond their reading level. Particularly, for the search result text R beyond grade-level six, we see that $R_{element}$ exhibits a positive correlation (+0.47) for clicked search results but a negative correlation (-0.40) for non-clicked search results. Here, a positive correlation score for clicked search results means that children's hover time increases as the text complexity increases for clicked search results. On the other hand, the negative correlation score for non-clicked search results indicates that the hover time decreases as the text complexity increases. As the clicked search results refer to active engagement, the correlation confirms that the text beyond the user's reading level requires them to spend more time comprehending the search result. This finding partially aligns with existing research work by Landoni et al. [15] where they found that children will browse more SERP snippets and search results while addressing easy tasks.

3.3 Navigation & Readability

After analyzing the text complexity R of clicked and hovered sequences, we found Kendall τ 's correlation scores of +0.63 for clicked navigation sequences and +0.62 for hovered navigation sequences. These positive correlation scores indicate that users' navigation of the search results started with lower text complexity and ended with higher text complexity. This means that often children start with the easiest to comprehend resource snippets. Although they frequently navigate linearly, this means they would start not necessarily at the top, but at an easy to read snippet.

4 CONCLUSION, LIMITATIONS, AND FUTURE WORK

In this paper, we undertook steps to understand how children engage with SERPs. Using user search logs generated by children (ages 6 - 12) who used a child SE, CSE, to analyze common behavioral metrics, clicks and hovers, from the data that signaled engagement. Children navigated a SERP sequentially by interacting with top results first before interacting with lower ranked results. Even with their observed preference to interact with top results, we found that children did not have linear rates of interaction (through CHR). Instead we found that as children navigate through the top results (r_1 - r_3) children's CHR will decrease and bottom out in the middle of the SERP between r_4 - r_6 . The rate of interaction then increases sharply at the lowest ranked results (r_7 +). This behavior is not yet fully explained- partially due to the limited sample size and lack of user sentiment around these bottom results in our dataset.

In calculating the readability scores from the result snippets by leveraging the Spache-Allen readability formula, we found that children tend spend more time hovering on snippets that are above (grades 7-12) their perceived reading level compared to snippets that are closer to their reading level (grades 1-6).

The sample size ($n=353$) considered in our study is relatively small and only relatively few users navigated to the bottom results on the SERP. While smaller sample sizes are not uncommon in research involving children [2, 4, 16], performing similar analyses on larger search logs, on data from more than one child-centric SE, would be a good next step. A significant portion of user clicks occurred with very little hover time and this behavior was largely unexplored in our study. A future analysis of what drives users to be decisive could be illuminating on children behavior on SE in general, as we found extended periods of indecisiveness (evidenced by long hover times on results) yielded fewer clicks.

In this work-in-progress we used logs from CSE to provide an overview of children's engagement with a SERP using clicks and hovers, investigate how those relate that to readability, and investigate if readability affects the path they took while navigating the SERP. Understanding children's engagement with SERPs is the first step towards yielding insights into how children are able to effectively accomplish their information seeking tasks.

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