How K-12 Students Search For Learning?
Analysis of an Educational Search Engine Log

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ABSTRACT

In this study, we analyze an educational search engine log for shedding light on K-12 students' search behavior in a learning environment. We specially focus on query, session, user and click characteristics and compare the trends to the findings in the literature for general web search engines. Our analysis helps understanding how students search with the purpose of learning in an educational vertical, and reveals new directions to improve the search performance in the education domain.

Categories and Subject Descriptors

H.3.3 [**Information Storage Systems**]: Information Retrieval Systems

1. INTRODUCTION

Search is a key web activity among all kinds of users towards a large variety of goals. While the lion's share of previous works on query analysis focus on general web search, the need for analyzing the search behavior of certain user groups and/or users searching for a certain type of information has emerged as an important research direction. Recent studies show that children and teenagers, who constitute a large and dynamic subset of web users, deserve special attention as their search behaviour differ from the adults in several ways while using search engines [6, 3, 2]. Other studies address alternative search tasks that are usually carried out via verticals, and analyze query logs obtained from the systems specialized for digital libraries, audio-visual archives and earching people on the web [8].

In this paper, we analyze the query logs of a commercial educational content developer and service provider for Turk-
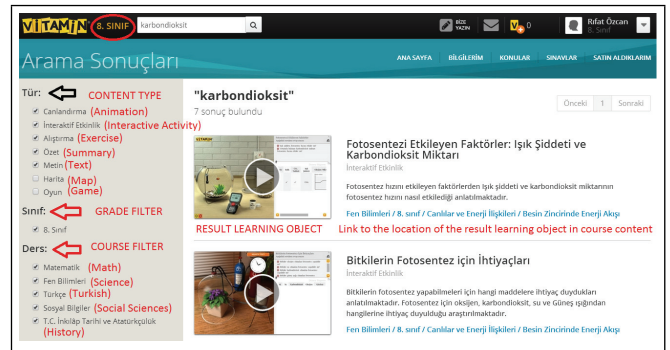
Figure 1: Vitamin search GUI for the query *carbon dioxide* (with annotations in English)

ish students at K-12 level. Turkey has the youngest population in Western Europe (by median age) and 42.9% of its total population, which is estimated to be around 77 millions as of December 2013, is young, i.e., younger than 24 years old. According to national statistics, the number of students at primary and secondary schools adds up to 16,156,519 (excluding pre-school and open-education students)[1]. Not surprisingly, there are several governmental and industrial efforts to develop education services and products targeting this young and dynamic population. Vitamin™ is a commercial web-based educational framework that provides interactive content and performance assessment mechanisms for a large variety of courses covered in K-12 curriculum in Turkey. As of December 2013, Vitamin has more than 1.2 million registered users and about 4.3 million site visits per month. These users can utilize the navigational interface to reach to the content they need, or they can perform search over the entire set of educational materials (Figure 1).

Following the practice in [8], we provide the characteristics of search in Vitamin with respect to four major dimensions; namely, queries, sessions, users, and clicked results. We also compare and contrast our findings to those on general web search engines and/or earlier results on children's search behaviors. Our analysis helps understanding how students search with the purpose of learning in an educational vertical, and reveals new directions to improve the search performance in the education domain.

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[1] http://sgb.meb.gov.tr/istatistik/

Table 1: Query characteristics		
Number of queries	66,908	
Number of unique queries	18,638	(27.8%)
Number of singleton queries	12,926	(19.3%)
Average number of queries per day	2,230	
Busiest day in number of queries	3,855	
Average number of terms per query	2.16	
Average number of users per query	3.58	
Average number of results per query	114	

2. ANALYSIS

Vitamin search engine allows users to issue a keyword query along with a number of category filters, namely, content type, grade, and course filters. Figure 1 shows the GUI of the Vitamin's search system for the query "carbon dioxide". Then, users can click and display a particular query result, which is called a *learning object* and presented in text and/or audio-visual formats; or navigate to certain point in a topic hierarchy where this learning object belongs to. The system stores the queries and clicked results in the search log, while the navigational type of interaction is recorded separately as a different kind of event. Therefore, our preliminary analysis here involves a query log that includes a sample from the queries submitted to Vitamin's search system in December 2013 by the logged-in users (i.e., with paying or trial accounts), and followed by at least one click on the displayed results.

Query characteristics. According to Table 1, 27.8% of the query volume are unique queries and 69.3% of the latter are singletons, i.e., asked only once. These values differ from the web search trends, where 50% of the queries in a typical search log are unique and 88% of them are singletons [1]; and more similar to the trends obtained for a vertical for searching people [8]. This means that the queries are more likely to be repeated in this educational search engine, which is a good news for the mechanisms that exploit temporal locality, such as caching. On the other hand, distribution of query frequencies shown in Figure 2 (left plot) confirms the power law distribution characteristics as in the case of web search [1].
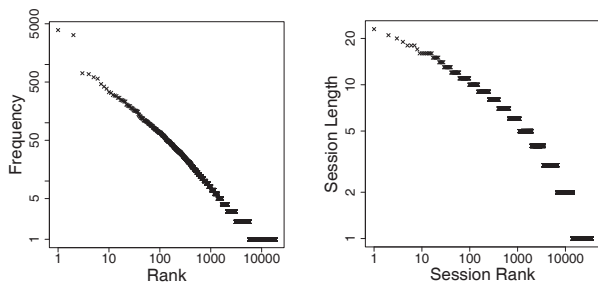

Figure 2: Distribution of query frequencies (left) and session lengths (right). The x-axis represents the rank according to the query frequency (session length) in the left (right) plot, respectively.

On the average, a query includes 2.16 terms, which is slightly shorter than typical web queries (around 2.5 terms as reported in [1]) as well as the queries submitted to a major web search engine by the users between 10 and 18 years old (around 2.6 terms [6]). This difference might be attributed to the fact that the educational search setup is a more re-

Table 2: Top-10 popular queries.		
Query	**Frequency**	**Users**
oyunlar (*games*)	3898	2290
oyun (*game*)	3197	1576
fen (*science*)	708	320
zarflar (*adverbs*)	683	466
türkçe (*Turkish*)	605	344
matematik (*math*)	571	368
fiilde çatı (*verb forms*)	461	321
ses bilgisi (*phonetics*)	417	248
standart sapma (*standard deviation*)	384	309
olasılık (*probability*)	335	249

stricted domain than web and even a couple of terms can yield the relevant resources from the available content.

Table 2 lists top-10 most frequent queries, which yields interesting findings. First, top-2 queries are "games" and "game", which means that the students enjoy the educational games provided by this system. Among the remaining 8 queries, 3 of them are simply the course names and too general to be useful (i.e., "science", "math", "Turkish"). This implies that the students who want to find a certain course still use the search box, rather than browsing through the list of courses. The other popular queries are related to Turkish and Math courses, and might be related to the topics that are being discussed in these courses at this time of the year.

As mentioned before, Vitamin's search interface allows setting various filters along with a query, which we analyze next. Figure 3 shows the distribution of content type filters selected while submitting queries. It is seen that all content types are selected in the majority of the queries, which is the default setting in the GUI. This means that users leave this filter as-is most of the time, probably because they want to see all available content relevant to their query. We observe similar trends for the use of course filter, as shown in Figure 5. In contrast, the grade filter, at a first look, seems to be used more effectively as the majority (more than 70%) of the searches are restricted to a certain grade level (Figure 4); grades 5, 6 and 7 being the most popular ones. However, this difference in the behavior may not necessarily be caused by the students' awareness of this filter, as the search GUI for the trial accounts, by default, shows only the user's own grade level as selected. Therefore, for most of the searches, we can still claim that students are reluctant to change the default filter settings, confirming the results in [4]. This is an interesting finding that deserves further analysis, as it can provide useful insight for designing a better search interface.
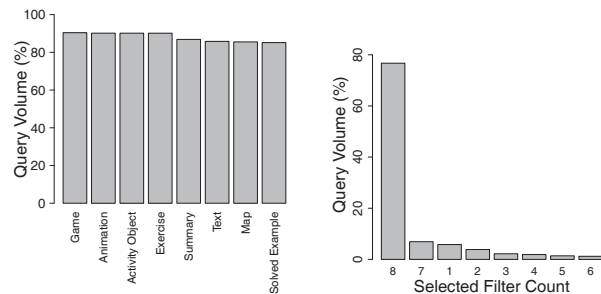

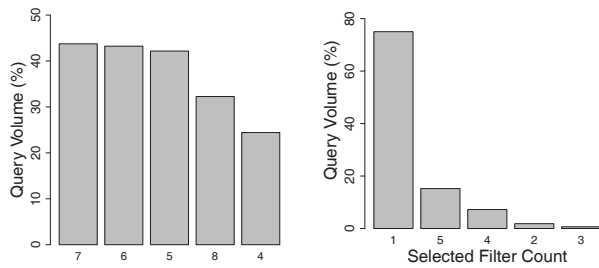Figure 3: Distribution of content type filters used in queries.

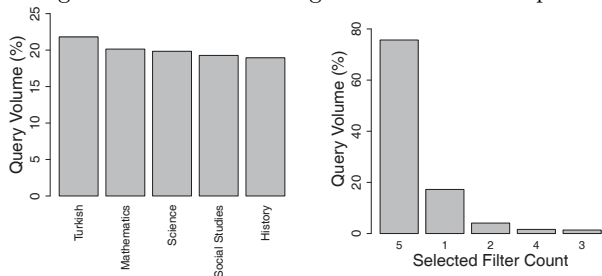Figure 4: Distribution of grade filters used in queries.

Figure 5: Distribution of course filters used in queries.

Table 3: Session characteristics

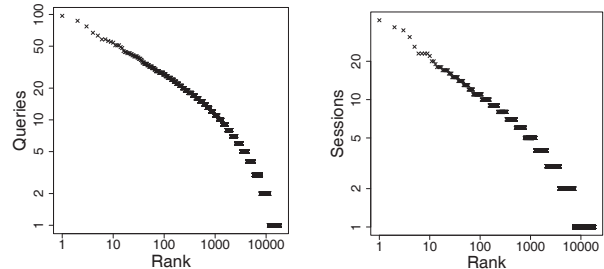| Number of sessions	35,225	
Number of sessions having single query	20,914	59%
Avg. num. of queries in all sessions	1.74	
Avg. num. of queries in sessions with > 1 query	1.86	
Longest session duration	133 min	
Avg. duration in all sessions	4.7 min	
Avg. duration in sessions with > 1 query	7.1 min	

Figure 6: Distribution of number of queries (left plot) and sessions (right plot) over users. The x-axis represents the rank according to the number of queries (sessions) per user in the left (right) plot, respectively.

Session characteristics. As in the previous studies [6], we detect sessions by grouping together a particular user's successive searches that has a time gap less than a time-out value (30 minutes). Table 3 presents several statistics about query sessions. Among the total of 35K sessions, about 59% include only one query. This skewed distribution of session length in number of queries can be seen in Figure 2 (right). Users submit around two queries in a session on average (computed by macro-averaging over users). The average number of queries submitted to a commercial search engine is 2.4 [7]. The average session duration in our log is 4.7 minutes and this is slightly longer than the session duration for children (between ages 6-18) reported in [6]. However when it is compared to a general user's query session in a web search engine (around 7 minutes in [7]), it is shorter. This again indicates that the students can effectively find what they look for in this context of educational search.

User characteristics. We present the characteristics of users in Table 4. Among 18K total users, 40% of them issue only one query during the one month period of our log. This skewed distribution can also be seen in Figure 6 (left plot), where a large portion of users asks very few queries but a few users submit large number of queries. The distribution of the number of sessions over users shown in Figure 6 (right plot) is even more skewed since 60% of users interact in only one session. On the average, users ask 3.61 queries in 1.92 sessions.

Figure 7 shows the distribution of query submissions over time. Monthly analysis (left plot) shows weekly patterns clearly. Students submit the largest number of queries on Sunday and least number of queries on Friday, according to the daily analysis in Figure 7 (center). This provides some interesting clues in students' studying habits: the students heavily search for information on Sunday, while they might be doing the homeworks for the upcoming week. Then, their activity in the search engine decreases gradually in the weekdays and reach the minimum on Friday, when most of the students seem to enjoy the weekend. Hourly analysis in Fig-

ure 7 (right) shows the percentage of queries submitted to the system in different hours of a day separately for weekdays and weekends. It is seen that students prefer to use the system mostly between 18:00-21:00 on weekdays (after school) and between 12:00-21:00 on weekends.
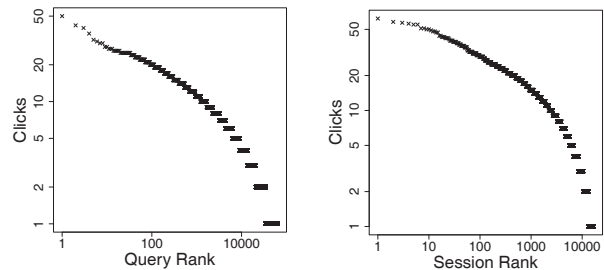

Figure 8: Distribution of click counts per query (left plot) and per session (right).

Result-click characteristics. In this part, we analyze the clicks on the query results. We find a total of 155,537 clicks in our log and, on the average, users click 2.56 results per query and 5.33 results per session. The log-log scale plots in Figure 8 shows that the distribution of number of clicks is again skewed and for the majority of the queries (and sessions), only one result object is clicked.

Figure 9 (left) shows the percentage of clicks for each type of learning objects. It is seen that users mostly prefer "animation" and "interactive exercise" type of contents. Furthermore, "interactive activity" and "lecture" type of contents are also clicked frequently, while textual resources ("Text") are less likely to be clicked. These findings reflect the students preference of interactive content over purely textual material, which actually leads most educational content to be presented in the former format in Vitamin.

Finally, we focus on the ranks of the clicked results in Figure 9 (right). We see that while top-2 results, non-surprisingly, take the largest share of the clicks, there is
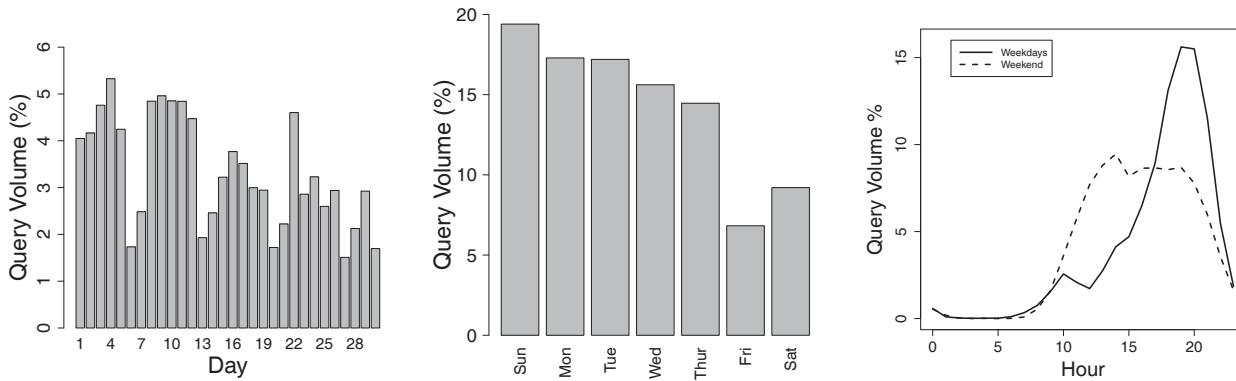
Figure 7: Distribution of query submissions over time. Left: Number of query submissions per day in December 2013. Center: Distribution of queries over weekdays. Right: Percentage of queries submitted per hour of the weekdays and weekend days.

Table 4: User characteristics

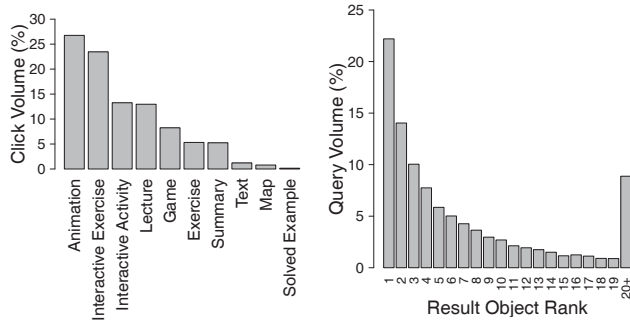|		
Number of users	18,534	
Number of users with > 1 query	11,402	62%
Number of users with > 1 session	7,590	40%
Avg. num. of queries per user	3.61	
Avg. num. of queries per user with > 1 query	5.24	
Avg. num. of sessions per user	1.92	
Avg. num. of sessions per user with > 1 query	3.31	

Figure 9: Distribution of result-clicks by content type (left) and rank (right).

a non-negligible fraction of clicks for the results placed at much lower ranks, even after rank 20. According to a general web search engine log [5], clicks for top-2 results account for 58% of all clicks and only 9% of clicks are below rank 10. However, in our log, top-2 clicks and clicks after rank 10 constitute 36% and 20% of all clicks, respectively. This might either indicate the students' dissatisfaction of the results, or their preference to see several relevant results while learning a topic. In our future work, we plan to conduct user studies to gain more insights into students' search behaviour. Furthermore, the existence of clicks at lower ranks indicates that there might be room for improving the ranking algorithm, which is another future work direction.

3. CONCLUSION

In this work, we presented an in-depth analysis of a query log from a popular K-12 educational search system with real user queries. Our analysis revealed that the trends in this context differ from general web search in various aspects, which might be exploited for building educational search engines that are better tailored for students' needs and be-

haviors. In particular, the high fraction of repeated queries indicates that system components that rely on the query history (such as caching and query suggestion) can be made more effective. The students' preferences in using the query filters call for reconsidering the design of the search interface. Finally, our result-click analysis shows that students prefer active content formats (like animations and interactive lectures) over the static content (like text) and can click further lower ranks in the results list other than the first few results. Such findings can help designing better features for the machine-learned ranking algorithms and lead higher user satisfaction, which is our future research direction.

Acknowledgements

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