An Empirical Study of University Students' Online Information Retrieval Competence Through Search Engine Use

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Abstract

The Internet has become a crucial information source for knowledge acquisition, and search engines are the primary tools for accessing online information. Through users' evaluations of the search engines they employ, the service quality of search engines can be assessed, while also indirectly reflecting users' online information search capabilities. This study examines from the perspective of university students' search engine usage, conducting an empirical investigation into the service quality of three comprehensive search engines and three vertical search engines across eight dimensions: "comprehensiveness", "timeliness", "relevance", "professionalism", "conciseness", "diversity", "organization", and "low interference". The findings reveal that university students generally lack awareness regarding search engine utilization. Aiming to improve students' search quotient (SQ), this article proposes a series of guiding recommendations for both students and universities to foster the enhancement of students' information literacy.

Full Text

An Empirical Study of College Students' Network Information Search Ability: Based on Search Engine Usage

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Abstract

The Internet has become a crucial source of information for learning, and search engines are the primary tools for accessing online information. User evaluations

of search engines can reflect service quality while indirectly revealing users' network information search capabilities. From the perspective of college students' search engine usage, this paper empirically examines the service quality of three comprehensive search engines and three vertical search engines across eight dimensions: comprehensiveness, timeliness, relevance, professionalism, brevity, diversity, organization, and low-interference. The study finds a general lack of awareness regarding search engine usage among college students. Aiming to improve students' "search quotient," this article proposes a series of recommendations for both students and universities to promote the enhancement of information literacy.

Keywords: information quality; search engine; user evaluation; information literacy education

In this era of highly developed internet and proliferating information, we face both the best and worst of times. The diversity of search engines, intelligent search technologies, and massive information volumes do not necessarily guarantee accuracy. Particularly in this age where rapid internet development has driven explosive growth in self-media, conflicting claims, survivor bias misguidance, and severe information asymmetry all influence information seekers' choices. More critically, in recent years, the United States has waged relentless public opinion warfare against China, cultivating online influencers and paid trolls to employ tactics such as concept substitution, false causality, and truth reversal, thereby confusing domestic public opinion, disseminating low-quality information, and creating conflicts. This undoubtedly poses a unique test of college students' information retrieval abilities, representing new requirements for high information literacy, advanced search skills, and strong value judgment capabilities in the new era, and will become new content for university information literacy education and a new dimension for enhancing students' comprehensive capabilities.

College students, due to the unique characteristics of their life stage, exhibit extremely urgent, voluminous, and highly proactive demands for information. Meanwhile, online information has become a vital source for their learning, owing to advantages such as low acquisition cost, fast access methods, and large content reserves. As the saying goes, "To do a good job, one must first sharpen one' s tools." To obtain high-value information, college students must possess advanced information search capabilities, and selecting more efficient search engines has become inseparable from cultivating such abilities. Correspondingly, alongside the competitive development of internet enterprises and technology companies, while traditional search engine functions are continuously refined, more distinctive and differentiated new search engines have emerged in the market—some featuring minimalist design, others leveraging massive self-media content advantages—all competing for user attention.

Evaluating network information search ability is a rather abstract and difficult-to-quantify concept. However, approaching it from the perspective of information quality obtained proves to be an operational strategy. Evaluating network

information quality should not only focus on its benefits but also consider acquisition costs (here referring more to time costs rather than economic costs). The benefits of information are determined by its content, while time costs are primarily influenced by interaction information. As a crucial tool for network information retrieval, search engines' provision of information content and methods correspond precisely to content information and interaction information, and these can be quantified. Zheng Lin, in "Research on Search Engine Quality Evaluation," also proposes that "the quality of a search engine depends not only on its own performance but also on the quality of its attached information database resources." This paper intends to use a questionnaire survey to establish a mathematical model comparing the search service quality of mainstream comprehensive and vertical search engines, ultimately providing guidance for students to improve their search quotient and for universities to conduct information literacy education.

Network Information Search Ability Evaluation Logic Model

1. Current Situation Overview

1.1 Status of Comprehensive Search Engines According to the 50th "Statistical Report on China' s Internet Development" recently released by the China Internet Network Information Center (CNNIC) in Beijing, as of June 2022, China' s netizen population reached 1.051 billion, with an internet penetration rate of 74.4%. This massive scale is unmatched by any other country in the world, and the search engine market has correspondingly become a huge cake. The largest share of this cake undoubtedly goes to Baidu. Benefiting from its first-mover advantage and aggressive expansion in earlier years, Baidu' s performance in the search engine market share during the first half of 2022 was exceptionally outstanding across PC, tablet, and mobile platforms. Except in the PC sector, where its market share shrank to 51.68% due to Bing, Sogou, and Google capturing 25.87%, 10.09%, and 7.23% respectively, Baidu dominates the remaining two sectors with nearly 90% market share, achieving a monopolistic position and absolute leadership.

1.2 Development of Vertical Search Engines In recent years, with the rapid development of self-media and the emergence of distinctive social platforms such as Douyin, Kuaishou, Weibo, Zhihu, Xiaohongshu, Bilibili, and WeChat Official Accounts, people' s search habits and preferences have undergone visible transformations. Taking Douyin, which has expanded overseas, as an example, according to the "2020 Douyin Data Report," its daily active users exceeded 600 million, with daily video searches surpassing 400 million. Compared with Baidu' s already achieved 1.54 billion daily searches for knowledge content in 2019, with knowledge vertical products serving over 230 million users daily, Douyin' s current impact is limited but its future potential is infinite.

1.3 State of the Search Engine Market The national-level search engine —Baidu—has long been criticized by the public for its overwhelming advertising promotions, disordered and highly repetitive search results, and poor display interfaces, causing users to constantly fall into reading traps. The domestic search engine market lacks a "catfish effect" due to Google being banned for national security reasons and domestic alternatives like Sogou and 360 Search having insignificant market shares compared to Baidu. Although the competitive atmosphere appears robust, the actual competitiveness is weak, giving Baidu a unique advantage to comfortably maintain its dominance based on early capital accumulation.

Given the intelligence and diversification of search engines, the diversification and humanization of functions, and their widespread and deep penetration, retrieving effective information should theoretically be as simple as breathing and as fast as lightning. However, the reality is that invalid, false, biased, and marketing-oriented information grows wildly like barnacles in the ocean of information, becoming a major obstacle for users seeking high-quality information and achieving value goals.

2. Literature Review

2.1 Literature Review

Research on search engine evaluation both domestically and internationally has generally undergone a cyclical process of proposing indicators, constructing indicator systems, and establishing mathematical models. Cleverdon et al. proposed the Cranfield evaluation model for information retrieval systems, dividing the indicator system into six aspects: coverage, precision, recall, response time, user burden, and output format of search results. Zheng Lin, in "Research on Search Engine Quality Evaluation," found that search functionality, precision, user burden, and output format are four basic indicators commonly used to evaluate network search engines or retrieval systems. Wang Jingjiang, in "Comparative Study on Search Engine Evaluation Indicator Systems," discovered through research on seven domestic and international evaluation systems that search capability (recall and precision), user burden, and search results consistently appear as core indicators, representing the minimum requirements for search engine evaluation.

Jin Yan and Yang Kang, in "Research on Information Quality Evaluation Indicator Systems Based on User Experience—From the Perspective of User Cognitive and Emotional Needs," constructed a three-level information quality evaluation system comprising 24 atomic indicators including utility, brevity, and timeliness, starting from two primary indicators (cognitive and emotional) and subdividing them into two secondary indicators (content information and interaction information). In "Research on Search Engine Evaluation Based on the CCSI Model," Jiang Weiwei employed the 1-9 scale method in the Analytic Hierarchy Process (AHP), combined with the Delphi method, to determine weights based on the

relative importance of evaluation indicators and synthesized the weights to construct a network search engine evaluation system based on the China Customer Satisfaction Index. Zhang Guohai et al., in "Construction of Search Engine Evaluation Indicator System Based on Entropy Weight," creatively introduced entropy weight to reassign weights to numerous indicators in the search engine evaluation system, effectively reducing the strong subjective coloring in traditional evaluations. Liu Zhengchun, in "Research on Comprehensive Search Engine Evaluation Model," used the proportion calculated by the entropy method to revise the weight vector determined by AHP, improving the rationality of weight determination, then employed the ELECTRE method to construct superiority and inferiority matrices, obtaining a comprehensive superiority judgment matrix, and ranking search engine quality by adjusting thresholds. Wang Xinfan, in "Multi-level Grey Evaluation Model for Search Engine Functionality," similarly used AHP to determine indicator weights, established scoring grade standards, organized expert scoring, determined evaluation grey classes, calculated grey evaluation coefficients, and calculated grey evaluation weight vectors and matrices to ultimately establish a multi-level grey comprehensive evaluation model. Wei Hongmei, in "Quantitative Evaluation of Search Engines," constructed an indicator hierarchy system through AHP, used the SAATY 1-9 scale method to determine ratio scales between factors, then applied the root method to calculate the judgment matrix obtained above to derive weights for indicators at each level, and finally invited experts to independently score four search engines, adding the scores of the lowest-level indicators multiplied by their weights to obtain scores for upper-level indicators, and multiplying upper-level indicator scores by their weights to obtain final scores for each search engine.

The author believes existing search engine evaluation models still have flaws. First, when constructing search engine evaluation models, they ignore that different indicators contribute differently to information value and aggressively pursue ranking search engine quality. Second, although some models have noticed weight differences, their logical consideration of relationships between indicators is limited to additive relationships, tending to assume indicators are independent and parallel, while failing to recognize that some indicators have inclusive or intersecting relationships.

The value of this paper lies in constructing a search engine evaluation model based on user-evaluated indicator weights that reshapes the logical relationships between indicators.

2.2 Indicator Determination

Based on the characteristics of search engines in this study, the following indicators are extracted and utilized from those summarized by Cleverdon, Jin Yan, Yang Kang, and others:

1. **"Comprehensiveness"**: Adapted from "coverage range" and "recall rate," this indicator represents the quantity of information provided by search en-

gines. Since comprehensive search engines sometimes cover content from vertical search engines due to their broad scope, while vertical search engines typically do not cross services, "Comprehensiveness"adopts a relative indicator form for comparison within the same search engine category.

2. **"Timeliness"** : An absolute indicator concerning the proportion of timely information among all provided information, requiring information to be updated promptly and keep up with current events, introduced based on the characteristics of the survey direction discussed later.

3. **"Relevance"**: Introduced based on Ma Zhijie's judgment in "Comparative Study on Domestic and International Search Engine Evaluation"that "relevance is the main theme," representing the proportion of information with high keyword overlap among all provided information. This addresses the need to eliminate redundant information interference and irrelevant information intrusion, while also testing information relevance.

4. **"Professionalism"** : Represents the proportion of high-value information among all provided information, requiring authoritative information sources and databases, and serving as an important test of information value. This indicator integrates three atomic indicators: "accuracy," "reliability," and "objectivity."

5. **"Brevity"** : Responds to the "user burden" indicator, derived from atomic indicators "brevity" and "applicability," meaning information content is concise with minimal redundant impurities, quickly satisfying user needs.

6. **"Diversity"** : Feedback on the "search result output format" indicator, evolved from the atomic indicator "diverse representation," referring to search results being output in various forms such as text, images, and video to meet users' diverse needs.

7. **"Organization"** : Also introduced based on Ma Zhijie' s judgment in "Comparative Study on Domestic and International Search Engine Evaluation" regarding the increasingly important research trend of "search result ranking quality." Considering that relevant results appearing at the top can effectively reduce search costs, this is indispensable for interaction information quality.

8. **"Low-interference"**: Derived from the atomic indicator "low-interference" and also feedback on the "user burden"indicator. Considering search engine companies' pursuit of economic interests, the density of their marketing strategies on their own search engines will inevitably affect user search experience, making this indicator' s introduction highly necessary.

9. Other indicators are eliminated due to insignificant differentiation across the six search engines, minimal role, low user perception, or high overlap with other indicators.

3. Survey Content

3.1 Questionnaire Design

With the ongoing impact of the post-pandemic era and increasing domestic economic downward pressure, "civil service and postgraduate entrance exams" are gradually replacing "employment" as the top choice for fresh graduates. Therefore, this survey targets 2,600 junior and senior students from Shandong University, Ocean University of China, China University of Petroleum (East China), Shandong Normal University, Qingdao University, Shandong University of Science and Technology, Shandong University of Finance and Economics, Shandong Agricultural University, Jinan University, and Qufu Normal University who are currently preparing for civil service or postgraduate exams. The survey focuses on the "civil service and postgraduate exam" direction.

The questionnaire comprises three modules. The first module contains 9 multiple-choice questions investigating comprehensive search engines. Respondents select the most frequently used search engine from Baidu, Sogou, 360 Search, Bing, Yahoo, and Ecosia when preparing for exams, and rate it using a 5-point Likert scale across eight dimensions: comprehensiveness, timeliness, relevance, professionalism, brevity, diversity, organization, and low-interference, as shown in Table 1 . The second module is identical to the first, except the initial question asks respondents to select the most frequently used vertical search engine from Douyin, Kuaishou, Weibo, Zhihu, Xiaohongshu, Bilibili, and WeChat Official Accounts. The third module contains only 3 questions asking respondents to rank, based on personal perception: (1) the importance of content information versus interaction information to information value, (2) the importance of comprehensiveness, timeliness, relevance, and professionalism to content information, and (3) the importance of brevity, diversity, organization, and low-interference to interaction information.

The survey ultimately collected 2,458 responses. The first module yielded 1,931 valid questionnaires, from which 1,776 questionnaires ranking the top three search engines were selected. The second module yielded 1,895 valid questionnaires, from which 1,694 questionnaires ranking the top three vertical search engines were selected. The third module yielded 2,371 valid questionnaires, all of which were used.

3.2 Data Summary

Figure 2 [Figure 2: see original paper] presents the cumulative statistics of the most frequently used search engines ranked first. For comprehensive search engines, Baidu leads with 1,107 instances, followed by Bing with 377 and Sogou with 292. For vertical search engines, Douyin ranks first with 723 instances, followed by Bilibili with 563 and Zhihu with 408.

Figure 3 [Figure 3: see original paper] shows the rating distribution across eight indicators for the 1,107 users who listed Baidu as their most frequently used

search engine (data for other search engines are presented below).

Figure 4 [Figure 4: see original paper] displays the comparative vote counts for respondents' ranking of content information versus interaction information importance to information value.

Table 2 presents the cumulative comparative statistics of respondents' rankings regarding the importance of comprehensiveness, timeliness, relevance, and professionalism to content information.

Table 3 presents the cumulative comparative statistics of respondents' rankings regarding the importance of brevity, diversity, organization, and low-interference to interaction information.

4. Empirical Analysis

4.1 Research Hypotheses

Assumption 1: The service quality SQ (Service Quality) of a search engine is only related to "Comprehensiveness" Cd (the Degree of Comprehensiveness), "Timeliness" Td (the Degree of Timeliness), "Association" Ad (the Degree of Association), "Professionalism" Pd (the Degree of Professional), "Brevity" Bd (the Degree of Brevity), "Variety" Vd (the Degree of Variety), "Organization" Od (the Degree of Organization), and "Low-interference" Ld (the Degree of Low-interference). Therefore, assume the simplified function of search engine service quality is: relative indicator form of comprehensiveness. (+ + +)

In Figure 4' s contribution to information value, vote ratios of 1:9, 2:8, 3:7, and 9:1 for content information versus interaction information are too low and thus eliminated.

115$×4 + 217×5 + 794×6 + 924×7 + 221×$8 0.64

Assigning weights of 0.4, 0.3, 0.2, and 0.1 to first, second, third, and fourth positions in Tables 1 and 2 respectively:

1 − 0.64 = 0.36

115+217+794+924+221 = 0.4 × 146+143+549+1533 + 0.3 × 457+502+925+487 + 0.2 × 855+641+568+307 + 0.1 × 913+1085+329+44 0.19 = 0.19 = 0.27 = 1 − 0.19 − 0.19 − 0.27 = 0.35

Finally, the adjusted function is:

= 0.25 = 0.26 = 1 − 0.16 − 0.25 − 0.26 = 0.33

Assumption 2: When entering search term XXX, a search engine provides Y relevant results, with timely messages accounting for X%. Among these (Y*X%) latest messages, only W% are relevant, leaving (*YX%*W%) latest relevant messages. Due to a reliable information proportion of Z%, only (*YX%*W%*Z%)

messages have reference value. The four indicators contribute differently to content information value formation and are thus assigned corresponding weights. Additionally, interaction information comprising "brevity," "diversity," "organization," and "low-interference" will inevitably affect user search experience, with poor experience likely suppressing browsing desire and reducing the quantity of presented content information, hence its introduction into the function.

The relationships among the eight indicators are shown in Figure 5 [Figure 5: see original paper], with the overlapping area of the two circles representing information ultimately obtained by users.

Assumption 3: Among 1,107 Baidu users, 95 rated its comprehensiveness as 1 point, 151 as 2 points, 92 as 3 points, 566 as 4 points, and 203 as 5 points. The weighted average score is 3.57, and after normalization: $3.57/5 = 0.714$. This infers that 1,107 Baidu users believe Baidu provides 71.4% of network information resources on average. For timeliness: $172\$\times1 + 286\times2 + 156\times3 + 349\times4 + 144\times\$5$ 3.01, and $3.01/5 = 0.602$, meaning 60.2% of information provided by Baidu is timely. Other indicators follow the same logic.

4.2 Empirical Results

Based on Figure 3 and the eight-indicator data for the remaining seven search engines:

0.602 ·0.620 ·0.587 $0.16 \times 0.477 + 0.25 \times 0.685 + 0.26 \times 0.560 + 0.33 \times 0.397 = 0.6089$

Therefore, the ranking of search engine service quality from best to worst is: Bilibili > Bing > Sogou > Baidu > Zhihu > Douyin.

4.3 Empirical Validation

A "multi-level fuzzy comprehensive evaluation" model is used to conduct an appropriate comprehensive evaluation of search engine service quality.

The specific steps of multi-level fuzzy comprehensive evaluation are as follows:

1. **Factor set** U = {Comprehensiveness, Timeliness, Relevance, Professionalism, Brevity, Diversity, Organization, Low-interference}
2. **Evaluation set** V = {Excellent, Good, Medium, Qualified, Unqualified}

For each factor set, a fuzzy comprehensive evaluation must be conducted:

3. **Weight confirmation**
   $A_2 = [0.16\ 0.25\ 0.26\ 0.33]$
4. **Judgment matrix**
   $B_1 = A_1$ $R_1 = [0.19\ 0.35]$ $A_2 = A_2$ $R_2 = [0.16\ 0.25\ 0.26\ 0.33]$ R = A R = A_2 $R_2 = [0.64\ 0.36]$ R

Since 0.2968 has the highest membership degree, Baidu' s service quality is "Good."

- Bilibili: Maximum membership 0.3135; Service quality: Good
- Bing: Maximum membership 0.3027; Service quality: Good
- Sogou: Maximum membership 0.2933; Service quality: Qualified
- Baidu: Maximum membership 0.2813; Service quality: Excellent
- Zhihu: Maximum membership 0.2735; Service quality: Medium

Ranking by service quality: Bilibili > Baidu = Bing = Sogou > Zhihu > Douyin. For the three comprehensive search engines all rated as "Good," further ranking by membership degree yields: Bilibili > Bing > Sogou > Baidu > Zhihu > Douyin.

The ranking from the multi-level fuzzy comprehensive evaluation model aligns with that determined by the simplified search engine service quality function, validating the model' s effectiveness.

4.4 Empirical Summary

Based on the service quality functions of the six search engines: Among comprehensive search engines, Bing performs best due to excellent relevance and user experience, with significant advantages even over vertical search engines. Baidu, despite having the broadest user base, shows mediocre service quality due to weak information relevance and professionalism, preventing its advantages in comprehensiveness and freshness from being realized. Among the three emerging vertical search engines, Bilibili demonstrates strong comprehensive service quality due to impressive information relevance, professionalism, and experience.

The data indicates no absolute positive correlation between user numbers and service quality, suggesting a "bad money drives out good" phenomenon. The reasons can be divided into two aspects: First, differential development strategies and market sizes among comprehensive search engines. Benefiting from early aggressive expansion, major manufacturers have reached deep cooperation with Baidu, unanimously setting Baidu as the default browser on smart devices. Users have gradually developed usage habits and stickiness, incurring learning costs when adopting new search engines but easily abandoning exploration without significantly differentiated experiences. Second, users' vague cognition and simplistic usage methods regarding search engines. The survey found that less than 6% of respondents could clearly distinguish the differences and characteristics of these six search engines, with most understanding of comprehensive and vertical search engines remaining at the level of names and entertainment. This cognitive limitation likely causes non-selective usage, backward and inefficient search methods, and lack of comprehensive search resources.

5. Recommendations

5.1 Guidance for User Search Engine Usage

First, enhance the comprehensive utilization of search engines. Different search engines exhibit significant differences in service features, content characteristics, user profiles, and marketing strategies. College students should have a basic understanding of these profiles to reduce search blindness and select search engines purposefully for specific content. For example, Bilibili focuses on providing massive learning resources, Zhihu offers abundant experience sharing, and comprehensive search engines serve as important channels for official announcements.

Second, strengthen the ability to judge information value and authenticity. Assessing information's value and credibility has always troubled search engines, especially in the era of rampant self-media growth. Seemingly professional and scientific long-form content may contain "private goods," and even long-established organizations and individuals can face trust crises. Therefore, college students should pay greater attention to information source reliability, repeatedly verifying the persuasiveness of information through multiple platforms, multiple searches, and multiple publishers to achieve comprehensive synthesis, selective extraction, and rational reference of network information.

Third, expand new approaches and methods for information searching. Many social platforms have horizontally expanded their original services. For instance, WeChat, as a 熟人 social product, has launched the "Search" function. Based on its massive user base, numerous high-quality Official Accounts have emerged, providing relatively complete services in sorting, summarizing, and pushing real-time information. Additionally, many products promote their information resources in APP form, such as software focused on medicine and finance, which are currently popular. Related topics and forums also qualify as providers of quality information. Such information sources await active user exploration to accumulate richer and more extraordinary information resources for achieving value goals.

5.2 Recommendations for University Information Literacy Education

Currently, domestic universities prioritize moral education, intellectual education, physical education, aesthetic education, and labor education, while information literacy education, as an integration of moral and intellectual education, has not received widespread attention from most universities. Training content on search engines is particularly scarce. To promote students' comprehensive development, information literacy education should receive significant university attention, and its content should be supplemented and adjusted:

First, incorporate information literacy education into the public basic curriculum system. Adopt online courses using MOOC resources to achieve networking, fragmentation, and mobility of teaching content, providing humanized services for students to select courses as needed and on schedule, avoiding becoming an

assessment target that increases student burden and defeats its original purpose.

Second, internalize foundational knowledge as students' information literacy. The transformation from "learning" to "application" requires not only building a professional teaching team and strengthening faculty, librarians, and teaching assistants but also conducting practical activities such as information literacy competitions, knowledge tests, and discussion forums to deepen the imprint of information literacy education in students' minds, achieving internalization in the heart and externalization in action.

Third, incorporate information literacy education into comprehensive student ability assessment. Universities should gradually establish and improve information literacy evaluation standard systems, determining multiple indicators and multi-layer dimensions to clearly and decisively identify students' information awareness strength, information ability level, information concept novelty, and information theory knowledge.

Fourth, strengthen search engine retrieval ability training. Increase the proportion of search engine training content in information literacy education, such as search engine characteristics, usage skills, and exploration and utilization of search tools within engines. During the process of guiding students to use search engines for information retrieval practice, enhance their comprehensive application abilities, train their retrieval skills, and improve their search strategizing capabilities.

Note: Figure translations are in progress. See original paper for figures.