Usability Evaluation of Web Search Engines Using Informational Query Model Examples from Library and Information Services

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Abstract

The study was aimed at performing a usability evaluation of some selected general web search engines in order to reveal their usability performances based on their informational query model. In addition, the study adopted Joo, Lin and Lu (2011) usability evaluation model and Dirk Lewandowski (2012) framework for evaluating the retrieval effectiveness of web search engines, as theoretical foundation for undertaking the usability study. The research design used for the study was quasi-experimental design in which a study population of five web search engines, namely: Ask.com, Bing, Excite, Google and Yahoo! web search engines, were selected for the experiment. Twenty One master degree students from the Department of Library and Information Technology, Federal University of Technology Minna, Nigeria were selected as observation participants, who were trained and guided to carry out the experiment. The instrument used for data collection was an observation template used to record the observations made by the participants. The instrument was divided into three sections, each with five different informational query model examples drawn from Library and Information Services used to test the web search engines' usability performances using six usability effectiveness constructs developed by Joo, Lin and Lu (2011). One alternative hypotheses was formulated and tested using Friedman's ANOVA by rank. The study revealed that all the web search engines performed well and scored mean values above the benchmark of 2.5, though at different levels of performances. Specifically, Google has the highest performance on usability effectiveness using informational query model, as reflected in its overall mean score of 3.59. Yahoo! ranked second with an overall mean score of 3.49, the third is Ask.com which has the overall mean score of 3.37, followed by Bing with a mean score of 3.07 and lastly Excite which has an overall mean score of 2.70. In conclusion, all the search engines were effective and there is no significant difference in usability effectiveness among the web search engines using informational query model. It was recommended that all the web search engines should maintain or improve the usability effectiveness of the search engine with respect to the informational query model for better performance and consequently enhance user experience.

Keywords: Information Retrieval Tools, Informational Query Model; Library and Information Services, Usability Evaluation; Web Search Engines.

Introduction

Information retrieval tools came into being as a means of ensuring that information generated and recorded do not get lost over time. Information retrieval are mostly associated with libraries and information centres, and are mostly used to recall information stored in the libraries' collections. As the information held therein grew, several types of information retrieval tools or devices were also invented to cope with the vast amount of information and make them available to users (Unagha, 2010). Nowadays, the quantity of new information being generated is such that no individual can hope to cope with this information explosion and at the same time make them available and accessible to users. This led to the invention and use of information retrieval tools, which are devices designed to facilitate information searching and retrieval from a vast collection of information stored, be it paper-based or electronic. Libraries have also incorporated modern information retrieval tools in order to provide quick and innovative information services to their clienteles. These include the use of electronic databases, Online Public Access Catalogue (OPAC), and Internet connectivity, to enable their users search for information online through various web search engines (Uzohue & Yaya, 2016).

Moreover, information retrieval is concerned with the structure, analysis, organisation, storage, searching, and retrieval of information (Croft, Metzler & Strohman, 2015). According to Sanderson and Croft (n.d.), the advent of the Internet was not the beginning of the development of information retrieval tools, as a matter of fact, the general use of web search engines as information retrieval tools were mostly found in intelligence and commercial applications in the 1960s. The advent and development of the Internet and the World Wilde Web (WWW) in recent time has created vast amount of available information which are just a few clicks away, but these voluminous information demands for commensurate growth and speed for retrieval tools and mechanism that will assist information searchers to locate and retrieve the needed information for their use on the web (Kirchhoff, 2010). Interestingly, web search engines are the most widely used web based information retrieval systems today. The Internet has billions of websites with lots of contents but it is the web search engines that make them discoverable. Web search engines are important information retrieval devices used for searching and retrieving information on the web by researchers, students, lecturers, and the general public. Thus, web search engines are an integral part of the Internet, they serve as an intermediary between the information seeker and the huge collection of information resources on the web. When properly utilised, web search engines constitute a major source of information (knowledge acquisition) for researchers in doing their academic and scholarly engagements/assignments. It should be added that web search engines use crawler or spider, which are software program that traverse or navigate the web to find information on various servers. In addition, web search engines have three types of query models in accordance with the intent of users. These are informational, navigational and transactional. This study however, dwelled on the informational query model.

Informational query model of web search engines refers to query intent that aims at finding information about a specific subject or search for some documents on a topic. Informational queries are quite lucid, they cover a broad topic (e.g., librarianship or computer software) for which there may be huge number of relevant results about those subjects. When a user enters an informational search query into a web search engine, he/she is simply sourcing for information – hence the name. In this case, the user may not be looking for a specific site, as in a navigational query, and he may not be looking forward to make a commercial

transaction – he just wants to find information or answer a question or get knowledge about something (Gabbert, 2017). Queries such as "*What is cataloguing?"* is an informational query, its goal is finding the meaning of "*cataloguing*" (Kang, 2018). The main goal of informational queries are accessing and retrieving information, as such, no interaction beyond clicking and reading is required. Informational queries contains question words (i.e., "ways to," "how to," "what is", etc.), queries with natural language terms, queries containing informational terms (e.g., list, definition, concept, etc.), queries that were beyond the first query submitted, queries where the searcher viewed multiple results pages, queries that do not meet criteria for navigational or transactional (Jansen, Booth & Spink, 2007).

Statement of the Problem

Despite advancement in and multiplicity of assorted web search engines on the Internet, users are still not satisfied with the performances of some web search engines, due to unfriendly user interfaces and usability failures of the informational query model of the web search engines. The fact that different web search engines have different algorithms for retrieving and ranking search results, there are variances in their search outputs as well as their usability effectiveness and efficiency. Lewandowski (2012) posits that it is imperative to recognise that a web search engine that offers perfect results may still not satisfy the needs of the users, due to some other factors, such as usability failures of the system, often make users spend more time and effort in searching for information.

Moreover, there is knowledge void in the field of library and information science in applying usability metrics to evaluate web based information retrieval systems in Federal University of Technology Minna, Nigeria. Most researches of this nature adopt the traditional recall and precision ratios which have been over-flogged over the years. Since it is impossible to know the total number of documents on the web pertaining to a given query, calculating recall and precision would not be an absolute measure. Moreover, web search engines are designed for users. Thus, if the intended users of the system find it difficult to use or cannot use it at all, the system is a failure. Hence, the need for usability evaluation of web search engines in order to determine their usability performances. This study will fill the gap via the use of usability evaluation metrics as a veritable measure. It is against this backdrop that the researcher deems it befitting to undertake this research; to carry out a usability evaluation of web search engines using informational with examples drawn from library and information services. Ultimately, the results that will emanate from this research work will reveal the best web search engine(s) to use based on usability factors needed by researchers. Furthermore, it will assist researchers in the choice of web search engines as to its usability performance on informational coverage.

Objectives of the Study

The main objective of this study is to carry out usability evaluation of Ask.com, Bing, Excite, Google and Yahoo! web search engines. However, the specific objective of the study is to:

1. determine the usability effectiveness among web search engines using informational query model.

Research Questions

The following research question guided the study:

1. What is the usability effectiveness among web search engines using informational query model?

Research Hypotheses

The study formulated and tested the following null hypothesis at 0.05 level of significance:

H_{o1}: There is no significant difference in usability effectiveness among web search engines using informational query models.

Significance of the Study

The results of this study will be of great importance to students, educators, librarians, researchers and library administrators respectively. To the students, educators, librarians and researchers, this study will enlighten them on the appropriate web search engines to use when searching for relevant information online to accomplish their engagements/ assignments. In essence, this study will reveal the best web search engines among those selected for this study, to improve the quality of information at their disposal, and by extension improve the quality of their research works, and serve as a beacon to guide researchers out of the maze of the huge amount of information available on the Internet. This study will also provide huge knowledge bank to researchers on choice of web search engines using usability metrics.

Research Methodology

Quasi-experimental research design was used as the research design for this study. Quasi-experimental research design is most suitable for this study because the usability experiment conducted was not a complete experimental research, as there were no probability samples, control groups or random assignment of treatments. However, the experimenters or observation participants were situated in a computer laboratory with computers and Internet facilities to perform usability tests (experiment) on different web search engines and observe their usability effectiveness by manipulating them, and assessing the performances of their informational, navigational and transactional query models using query examples selected from Library and Information Services. According to White and Sabarwal (2014), quasi-experimental design is one in which a treatment comprising the elements of the programme/policy being evaluated, is tested for how well it achieves its objectives, as measured by a pre-specified set of indicators. In a quasi-experimental design, the researcher lacks control over the assignment to conditions and/or does not manipulate the causal variable of interest. That is, a quasi-independent variable is not manipulated by the researcher but rather is an event that occurred for other reasons.Quasi-experiments are the next logical step in a long research process where laboratory-based experimental findings need to be tested in practical situations to see if the findings are really useful (Fife-Schaw, 2012). Quasi-experimental research is research that resembles experimental research but is not a complete experimental research, hence the word "Quasi" (Price, Jhangiani& I-Chant, 2019).

The population for this study comprised of five (5) web search engines and twenty one (21) observation participants as study and test population respectively. The study population (experimental units) denotes the number of web search engines selected for this study while the test population refers to the individuals that were systematically selected to carryout the experiment and record the usability performances of the various web search engines selected for the study.

Table 1: Study Population of Web Search Engines

S/No	Web Search Engines	Web Address/Links
1.	Ask.com	www.ask.com
2.	Bing	www.bing.com
3.	Excite	search.excite.com
4.	Google	www.google.com
5.	Yahoo!	search.yahoo.com

Source: Author's concept

The rationale behind the use of these five web search engines for this study was because they are among the first 10 popular, most widely used and best search engines as reported by Dwyer (2016) and Ratcliff (2016). Furthermore, Jeyashree and Ravichandran (2012) believed that web search engines such as Bing, Google and Yahoo! can provide information for deep research work and give researchers unrestricted access to their hyperlinks structure plus large amounts of data regarding those links. Ask.com and Excite web search engines do the same. In addition, the five web search engines all have a percentage of the market share of web search engines worldwide as represented in Figure 1.

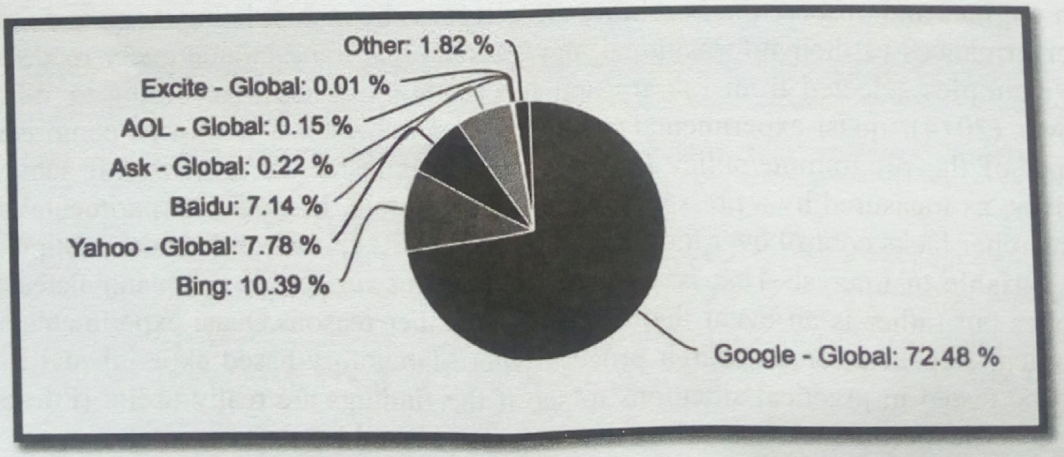

Figure 1: Market Share of Web Search Engines
Source: Ratcliff (2016)

According to Lewandowski (2012), students are mostly selected as jurors (observation participants) in studies of this nature, because they are easy to recruit and they can quickly perform tests and judge large numbers of questions, especially when this is in line with their coursework. In view of the foregoing, since the queries were drawn from library and information services, therefore, the test population (observation participants) were 21 master degree students in the Department of Library and Information Technology, Federal University of Technology Minna, Nigeria. Moreover, an observation template was used as the data collection instrument where the experimenters recorded their observations while carrying out the experiment.

Table 2: Library and Information Service Queries for Testing Informational Query Model

S/No	Queries	Query Number	Query Model Type
1.	How to manage collection development in the digital age?	Query 1	Informational
2	What are the effects of ICT on library services?	Query 2	Informational
3	What are the functions of indexing and abstracting services?	Query 3	Informational
4	What are the concepts of cataloguing and classification?	Query 4	Informational
5	What are the characteristics of serial materials?	Query 5	Informational

Source: authors' concept

Moreover, Joo, Lin and Lu (2011) usability evaluation model was adapted and used for the experiment, however, only effectiveness metric was implemented. The queries outlined in Table 2 were tested in all the web search engines for this study, and their usability performances were be measure based on the usability effectiveness constructs indicated in Table 3.

Table 3: Usability Evaluation Metrics

Usability Metric	Code	Item/Construct
Effectiveness	efy1	I can usually complete an informational search task using the search engine.
	efy2	I am successful in general in finding informational resource(s) using the search engine.
	efy3	Overall, the search engine is useful in helping me find informational needs.
	efy4	I usually achieve what I want using the search engine.
	efy5	The informational resources I obtain from the search engine are usually useful.
	efy6	The search engine usually covers sufficient informational topics that I try to explore.

Source: Joo, Lin and Lu (2011)

Validity and Reliability of the Research Instruments

The instrument was subjected to face, content and construct validation by 3 lecturers in the Department of Library and Information Technology, Federal University of Technology Minna, and 1 statistician in the department of test and measurement. In addition, the research instrument (observation template) was adapted from Joo, Lin and Lu (2011) usability evaluation model and modified to suite this research work. Consequently, the reliability of the research instruments was tested by conducting a pilot study to determine the reliability coefficient and internal consistency of the instrument. The pilot study was done using master degree students in the Department of Library and Information Science, Federal University of Agriculture Makurdi, Benue State, Nigeria. The results from the pilot study of the instrument was analysed using Cronbach Alpha Coefficient, and the value of the Alpha Coefficient was 0.950, which showed that the research instrument was excellently reliable; as Tavokol and Dennick (2011) submitted that if the value of the Cronbach Alpha Coefficient is ≥ 0.9, the instrument is excellent, if it is ≥ 0.8 and < 0.9, it is good, if $\geq 0.7$and < 0.8, it is acceptable, if $\geq 0.6$and < 0.7, it is questionable, if $\geq 0.5$and < 0.6, it is poor and if it is < 0.5, the instrument is unacceptable. From the reliability test results, the research instrument is excellently reliable and hence, was adapted for the study.

Data Analysis, Results and Discussion

Research Question One:

What is the usability effectiveness among web search engines using informational query model?

Table 4 presents the results of the usability effectiveness of the web search engines using informational query model.

Table 4: Usability Effectiveness among Web Search Engines Using Informational Query Model

Web Search Engines	Strongly Agreed (SA)	Agreed (A)	Disagreed (D)	Strongly Disagreed (SD)	Mean $\bar{x}$	Standard Deviation 6	Skewness	Rank
	f_1	f_2	f_3	f_4				
Ask.com	334	226	70	0	3.42	0.68	0.24	3rd
Bing	211	269	137	13	3.08	0.79	-0.74	4th
Excite	85	271	236	38	2.64	0.79	-0.06	5th
Google	402	188	38	2	3.57	0.62	1.02	1st
Yahoo!	319	285	23	3	3.46	0.59	0.02	2st
Mean	270.2	247.8	100.8	11.2				

Note: SA = 4, A = 3, D = 2, SD = 1. N = Total responses for each web search engine = 630 i.e 6 usability constructs * 5 web search engines * 21 respondents. Decision rule: mean ≥ 2.5 = pass mark, mean < 2.5 = low mark.

The mean of the group distribution for the informational query model was calculated using the formula:

$$Mean(\bar{x}) = \frac{[(4*f1)+(3*f2)+(2*f3)+(1*f4)]}{N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (i)$$

Where:

f_1 = frequency for SA (Strongly Agreed)

f_2 = frequency for A (Agreed)

f_3 = frequency for D (Disagreed)

f_4 = frequency for SD (Strongly Disagreed)

N = total number of responses for a particular web search engine for the informational query model = 630 (i.e. 5 queries * 6 usability constructs * 21 responses)

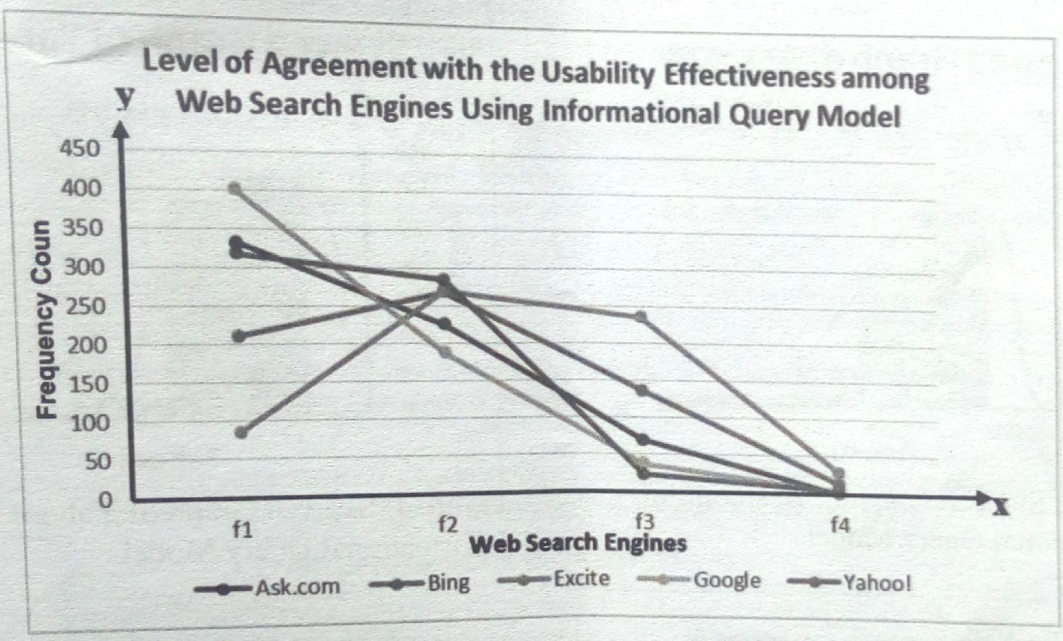

Figure 2: Level of Agreement with the Usability Effectiveness among Web Search Engines Using Informational Query Model

The usability effectiveness among the web search engines using informational query model is presented in Table 4.6 and Figure 4.4. The result revealed that Google web search engine ranked 1st in usability effectiveness using informational query model, with a mean value of 3.57. Yahoo! ranked 2nd with a mean value of 3.46, followed by Ask.com with a mean value of 3.42. Bing ranked 4th with a mean value of 3.08, and lastly Excite ranked 5th with a mean value of 2.64. The mean values of all the web search engines scored above the benchmark (decision rule) of 2.5, hence, they all performed well in their usability effectiveness though at different levels of performances.

Furthermore, the results revealed that the mean responses to the usability effectiveness of the selected web search engines using informational query model was highest for Strongly Agreed (270.2), followed by Agreed (247.8), Disagreed (100.8) and lastly Strongly Disagreed (11.2). This showed that, for the usability evaluation constructs/metrics itemized in Table 3.7, from efy1 – efy6, users can complete an informational search task using the search engines, users are successful in general in finding informational resource(s) using the search engines, the search engines are useful in helping users find their informational needs, users can achieve what they want using the search engines, the informational resources obtained by users from the search engines are usually useful, and the search engines usually covers sufficient informational topics they try to explore. Moreover, in experimenting these usability effectiveness constructs using informational query model, Google ranked 1st, followed by Yahoo!, Ask.com, Bing and lastly Excite, for the five (5) informational queries drawn from library and information services.

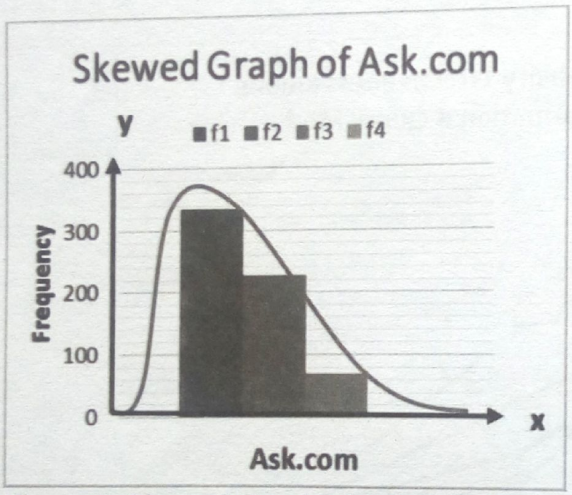

Figure 3: Skewed Graph of Ask.com for Informational Query Model

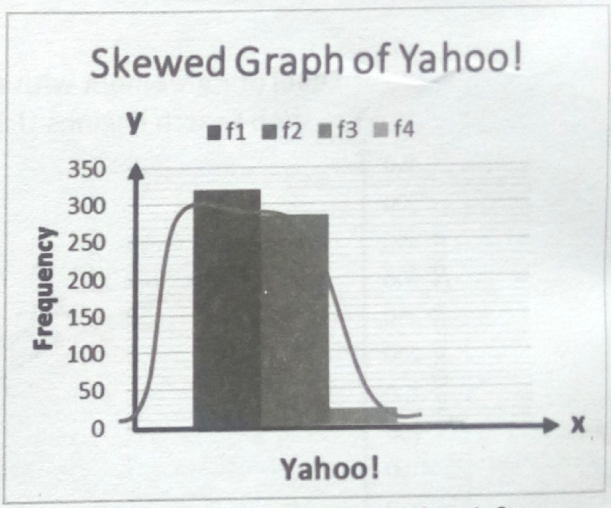

Figure 4: Skewed Graph of Yahoo! for Informational Query Model

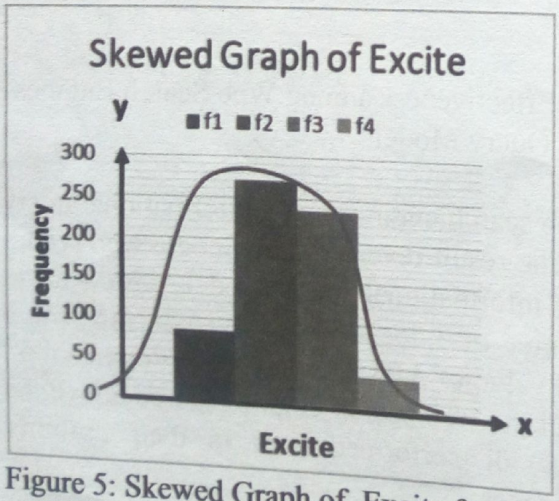

Figure 5: Skewed Graph of Excite for Informational Query Model

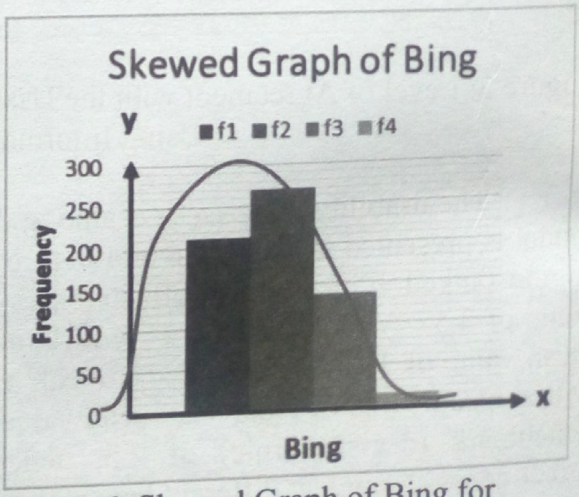

Figure 6: Skewed Graph of Bing for Informational Query Model

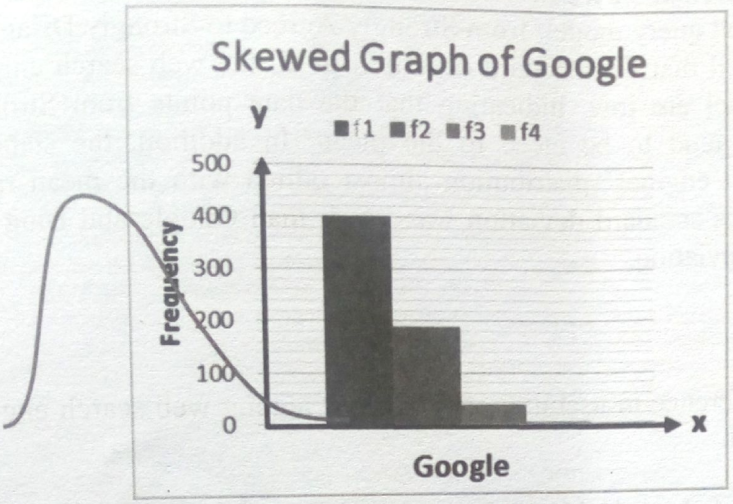

Figure 7: Skewed Graph of Google for Informational Query Model

From Table 4 and Figures 3, 4, 5, 6, and 7, the responses of the distribution for informational query model shows that Ask.com and Yahoo! were moderately skewed to the right with skewed values of 0.24 and 0.02 respectively, Google was highly skewed to the right with a skewed value of 1.02, while Bing was highly skewed to the left with a skewed value of -0.74 and Excite was moderately skewed to the left with a skewed value of -0.06. This explains the asymmetry or distortedness of the responses of the distribution about the mean (average) value for informational query model. Ask.com, Yahoo! and Google were on the positive side while Bing and Excite were on the negative side.

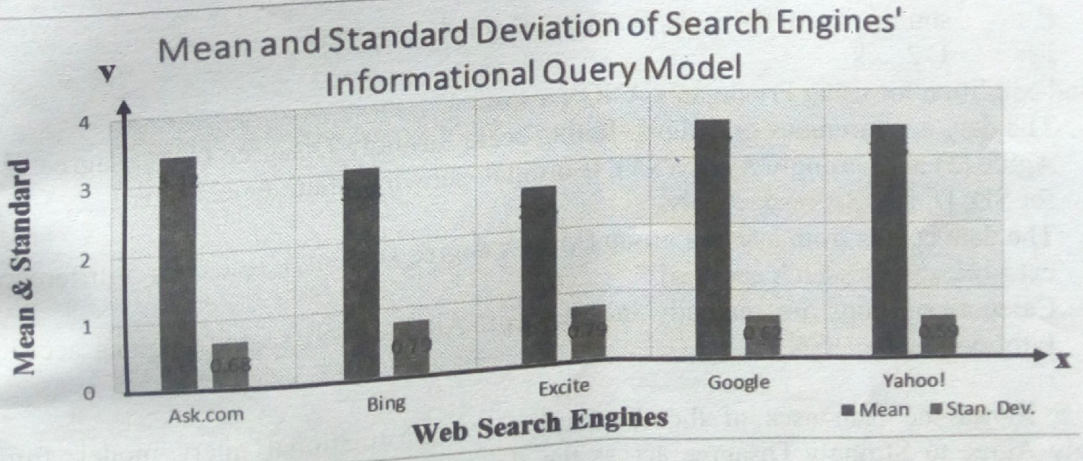

Figure 8: Mean and Standard Deviation of Web Search Engines' Informational Query Model

The Figure 8 shows the chart of mean values and standard deviation of each web search engine using informational query model, from Strongly Agreed to Strongly Disagreed respectively. The results revealed that the standard deviation of all the web search engines using informational query model are low, indicating that the data points from Strongly Agreed to Strongly Disagreed tend to be close to the mean. In addition, the standard deviation of all the web search engines' distribution almost tallied with the mean ranks accordingly, except that Yahoo's standard deviation was lower than Google and Bing and Excite have the same standard deviation.

Hypotheses Testing

H_{o1}: There is no significant difference in usability effectiveness among web search engines using informational query model.

Hypothesis Testing Method: Friedman's ANOVA by Ranks

The Friedman's ANOVA by rank is given by:

$$Fr = \left[\frac{12}{nk(k+1)}\sum_{i=1} Ri^2\right] - 3n\,(k+1) \quad \ldots\ldots (ii)$$

Where:

- k = number of categories/groups in the distribution
- n = number of responses/values in each category/group
- df= degree of freedom = k-1
- R = summation of the ranks in each category/group
- i = 1, 2,…k

Satisfied condition for using Friedman's ANOVA test:

1. The data is continuous or ordinal. Rating scale Strongly Disagree (1), Disagree (2), Agree (3) and Strongly Agree (SA), is ordinal, showing relative positions 1, 2, 3 & 4 for SD, D, A& SA respectively.
2. The data comes from a single group (Master degree students), tested on 5 difference categories (web search engines).
3. Categories/groups are mutually independent. All the web search engines accepts informational queries.

Table 5 shows the responses of the distribution for informational query model, from Strongly Agree to Strongly Disagree across the five web search engines selected for the study.

Table 5: Responses from Usability Effectiveness among Web Search Engines Using Informational Query Models

Ask.com	Bing	Excite	Google	Yahoo!
334	211	85	402	319
226	269	271	188	285
70	137	188	38	23
0	13	38	2	3

Table 6 shows the rank of the responses of all the search engines in ascending order, group by group, and the sum of ranks.

Table 6: Rank of Responses from Usability Effectiveness among Web Search Engines Using Informational Query Models

	Ask.com	Bing	Excite	Google	Yahoo!
	4	2	1	5	3
	2	3	4	1	5
	3	4	5	2	1
	1	4	5	2	3
Sum of Ranks	**10**	**13**	**15**	**10**	**12**

Using the Friedman's ANOVA by rank equation (*ii*), with an alpha (α) value of 0.05, and df of 4,

$$Fr = \left[\frac{12}{4*5(4+1)}(10^2+13^2+15+10^2+12^2)\right] - 3*5(4+1)$$

$$Fr = \left[\frac{12}{120}(100+169+225+100+144)\right] - 75$$

$$Fr = [(0.1)(738)] - 75$$

$$Fr = 73.8 - 75$$

$$Fr = -1.2$$

Table 7 shows the results of the Friedman's ANOVA by rank test statistics.

Table 7: Results of Friedman's ANOVA by Rank Test Statistics on Usability Effectiveness among Web Search Engines Using Informational Query Model

K-Value	Chi-Square Critical Value (χ^2)	P-Value
–1.2	9.487729	0.878099

Note: k-value = Friedman's ANOVA by rank test statistics, χ^2 = chi-square critical value, df = n-1

Table 7 shows the results of the computation of Friedman's ANOVA by rank test using informational query model, which revealed that the hypothesis was not significant (p-value = 0.878099, k-value = –1.2 and critical value (χ^2) = 9.487729), at an alpha (α) value of 0.05. Hence, the $H_{o1}$is retained. The results proved that there is no significant difference in usability effectiveness among web search engines using informational query model, as reflected in their mean values which were above the benchmark (decision rule) of 2.5.

Summary of the Major Findings

The summary of the major findings emanating from this study are:

1. The usability effectiveness among web search engines using informational query model is effective.
2. There is no significant difference in the usability effectiveness among web search engines using informational query model.

Discussion of the Findings

Research Question One: What is the usability effectiveness among web search engines using informational query model?

The responses of the respondents as to the usability effectiveness among web search engines using informational query model was presented in Table 4.7. The result revealed that Google ranked 1st, Yahoo! ranked 2nd, Ask.com ranked 3rd, Bing ranked 4th and lastly Excite ranked 5th. These results coincides with the study of Jadhav, Gupta and Pawar (2011) on evaluating the significant role of web search engine in higher education. Their study reported that Google ranked 1st from the respondents perceived relevance, Yahoo! ranked 2nd, MSN ranked 3rd, AltaVista ranked 4th and Lycos ranked 5th. Although MSN, AltaVista and Lycos were not used for this study, the rank of Google and Yahoo! web search engines across both research works, are pervasive.

Furthermore, this result corresponds with the work of Lewandowski (2014) on evaluating the retrieval effectiveness of web search engines using a representative query sample. Although the web search engines used by the researcher were only two (2): Google and Bing, the results are persistent. The author did a comparative analysis of his results across the two search engines and reported that Google ranked 1st. Furthermore, the author noted that the degree of finding the correct answer for informational queries was more accurate in Google than Bing, which places Google web search engine higher than Bing in performance using informational query model.

Conclusion

From the foregoing, the usability effectiveness among web search engines using informational query model is effective. There is no significant difference in usability effectiveness among web search engines using informational query models. i.e, all the web search engines performed well. Specifically, Google has the highest performance on usability effectiveness using informational query model, as reflected in its mean score. Yahoo! ranked second in usability performance, the third is Ask.com, Bing and lastly Excite. It could be inferred from the findings of the study that general search engines like: Ask.com, Bing, Excite, Google and Yahoo! could also perform specialised search services in library and information technology environment.

Recommendations

The recommendations of this study are:

1. Google, Yahoo!, Ask.com and Bing web search engines should maintain the usability effectiveness of their web search engines with respect to informational query model.
2. The facts obtained from this study revealed that Excite web search engine has the lowest mean score in usability effectiveness with respect to informational query model, although it passed the benchmark; hence, it is recommended that Excite web search engine's administrators should improve on the usability effectiveness of their informational query model for better performance and consequently enhance users' experience.

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