Modelling User-Centered Attributes: The Web Search Engine as a Case†

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Abstract: This paper modeled user-centered attributes with which First and Second-order Measurement Models (FSoMM) were proposed using factor analysis in a quantitative evaluative procedure. There was need to relate users needs as requirements for Web Search Engines (WeSEs) in a dynamic context. This informed the motivation for formulating the FSoMM to possess baseline properties with reasonable validity and reliability. This was achieved by considering how users "seek out and use" information as useful characteristics that can suffice as users' attributes. This is because of the belief in this paper that factors modelled from users' attributes encapsulate users' needs. With the qualitative evaluative approach these factors were translated into users' requirements for WeSEs' development. Results obtained showed that both models demonstrated reasonable model fit. Therefore, users' requirements can be communicated with measurement models. As illustrated in this paper, both the qualitative and quantitative evaluative approach remain an invaluable resource in this respect. We therefore infer that WeSEs' success in the delivery of assistance to users, particularly in a dynamic context must be based, not only on the progress of technology, but also on users' requirements.

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1.0 Introduction

The practice of evaluating all kind of Information Systems (ISs) can be difficult and confusing (Smithson 1994; Lagsten 2011). Today, this is been exacerbated by the pervasive, complex and interactive nature (Klecun and Cornford 2005; and Irani et al. 2005; as cited in Lagsten 2011) of Information Retrieval (IR) systems. All the same, evaluation is still an important topic for study in IS (Smithson 1994; Irani et al. 2005, as cited in Lagsten, 2011). The need for system appraisal, measurement of its success, and the recognition of its benefits (if any) (House 1980; Guba and Lincoln 1989, as cited in Stockdale et al. 2008), and the continual changes the IR system regularly undergoes that affects their interfaces are some reasons to continue to evaluate them (Gordon and Pathak 1999). The Internet, though robust, is fluxing in nature (Langville and Meyer 2012) and constitutes the dynamic context of the modern IR system. This also contributes greatly to the overarching need to continuously evaluate the system.

IR systems are veritable tools for knowledge organization (Mandl 2008). This includes the capturing, organizing, refining and disseminating of information using techniques of cataloguing and indexing, retrieving, filtering, and ranking (Chowdhury 2004). The system is versatile (Anderson et al. 2000; Shiri and Revie 2006; Li et al. 2008; Srihari et al. 2008), and useful for sundry search on the Web (Zimmer 2010). Thus, both structured and unstructured information (Ferrucci and Lally 2004) are easily accessed. The possibility for thesauri's inclusion in IR interfaces (Shiri et al. 2002; Shiri and Revie 2006) has also contributed (no doubt) to making the IR system a powerful interface for accessing the vast amounts of information available on the World Wide Web and beyond (Zimmer 2010). Thesauri have been recognized as a useful source for enhancing search-term selection for query formulation and expansion (Shiri et al. 2002; Shiri and Revie 2006).

Worthy of note is the fact that as the Web constantly changes, the needs of users as requirements also change. It is important that these requirements are related in such a way that they do not become obsolete, since they can serve as basis for others to be determined. Usually they do include a summary description(s) of the tasks that the system should support and the function(s) which supports them. These requirements may not evolve as the system is being developed. Formal user-centered evaluations may be required to determine users' needs as requirements at its formative stage (Maguire and Bevan 2002). But, at the summative stage of the system (like in the case of the WeSE under consideration in this paper), there will be need to adjust the system to suit specific or several purposes. When such system is in a dynamic environment as has been identified, evidently the needs of the users will change in the same proportion. The parameters to determine users' needs as requirements may not only change, they may go obsolete.

Following Coutaz et al.'s (2005) meaning of "context," Akhigbe et al. (2014) related users' needs to spaces designed to serve particular purposes. These researchers extended this meaning by expressing it as a state of predefined environment with a fixed set of interaction resources. They also considered it as part of the process of interacting with an ever-changing environment that is composed of reconfigurable, migratory, distributed, and multiscale resources (Coutaz et al. 2005). This current paper extends this same meaning to formulate measurement models with baseline properties in the first and second (or advance) order. It is therefore hoped that with these models a better way of relating users' needs as requirements is achieved. Consistent with e.g. Akhigbe et al. (2014), this current paper draws from the theory of measurement and constructivism to (i) be able to use users' attributes at the level of measurement, and (ii) introduce the concept of user-centricity to establish performance criteria from users' attributes. We believe users' attributes can convey users' needs, and from such needs users' requirements can be related. The user-centered IS evaluative approach is therefore explored to propose a baseline model to communicate users' needs as requirements of WeSEs. However, this paper is limited to the use of ordinal data from users' system usage in relation to user-system interactivity to model user-centered attributes. With the factor analysis (FA) technique users' needs as requirements with design implications are presented.

Though several works exist, and many methods have been developed over the years to evaluate IS, there is yet no unique model that evaluates all kind of ISs (Islam 2009). There is also no known measurement model – except the one presented by Akhigbe et al. (2014) that communicates users' needs as requirements. This paper builds on the work of Akhigbe et al. (2014) to model users' attributes as users' perceptions of WeSE. Thus, the possibility of modelling user-centered attributes is under-

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scored. On the other hand, since these attributes could encapsulate users' needs (Akhigbe et al. 2014), we debate that they can be used to relate (or specify) users' requirements. The motivation for this is the belief that IS will do better, if users' needs are identified, and are rightly appropriated. Therefore, this paper provides information on how to communicate users' needs to developers of IR systems. Furthermore, the paper progresses thus. In Section 2 the state-of-the-art is offered. Section 3 contains the WeSE and its context, with the methodology and theoretical foundations in Section 4, and in Sections 5 and 6, the proposed models and conclusion are presented.

2.0 Literature review

Interestingly, there are several works in this area. For instance, their focus is on user-centered variables such as those relating to Information Needs (INs), user intentions, personal characteristics, different user information seeking profiles, and the investigation of their relationship to term selection in the search process (Shiri et al. 2002). Particularly, the work of Smithson (1994) reported a longitudinal study concerning the evaluation of IR systems from within the context of User's Information-seeking Behaviour (UIsB). It also argued in favour of the pursuance of a more user-centered (interpretive) approach, like other proponents (Saracevic 1995; Dunlop 2000; Belkin 2008). Cognizant of this argument, this paper uses the user-centered evaluative paradigm to model user attributes. It moves a step further than that of Smithson (1994), by using the evaluative resource of User's Information behaviour (UIB). Within this context, the previous experiences of users – information behaviour, were harnessed with the belief that their knack for information search – UIsB were added to. We argue therefore that since users can construct knowledge, their evaluation of IR system will be invaluable. Like Smithson (1994) observed, the issue of user's information searching is dynamic. Thus, it is not ideal to look at evaluating IR systems from the perspective of the users based on their initial knowledge of the problem domain and information-seeking strategies alone. We believe that whenever users successfully use the IR system, or even after using the system and they are unimpressed, their knowledge of the problem domain and information-seeking strategies still improves. This we believe is further influenced by the UIB.

User-centered research efforts that leverage on end-users thoughts with a view to engendering better IR systems exists. The research efforts of Shiri and his colleagues are a few examples worthy of note. These efforts include (i) a review of literature that focus on studies which adopt a user-centered approach in a survey of methodologies and results from empirical studies on the use of thesauri as sources of term selection for query formulation and expansion during search process (Shiri and Revie 2006), (ii) the investigation of users' thought processes, perceptions, and attitudes towards the identification of user requirements for developing a full-blown pilot terminology service (Shiri et al. 2004), and (iii) the study of end-user query-expansion behaviour within the context of a thesaurus-enhanced search setting on the Web (Shiri and Revie 2006). While the effort of Shiri et al. (2004) underscored the fact that end-users' thought processes, perceptions, and attitudes can be harnessed for the evaluative good of ISs, the contributions of Shiri et al. (2002), and Shiri and Revie (2006) were toward a better user interface with thesauri facilities. However, this current paper differs from them based on (i) its theoretics, (ii) the data analytic technique with multivariate capability that is explored, (iii) the modelling of users' attributes, (iv) the communication of users' need(s) as requirements, and (v) the evaluative models presented. While usability formed the main theme in terms of the factor employed in Shiri et al. (2004), this current paper used multiple factors.

Evaluating performance remains a primary reason to evaluate IR systems (Smithson 1994). As a result, some earlier works (see Smithson 1994) showed considerable interest in this regard. Others works (e.g. Cheng et al. 2010; Lamm et al. 2010; van Schaik and Ling 2011; and Palanisamy 2013) – though quite recent, exist but did not examined system performance in terms of users' needs, nor communicate them as users' requirements in a dynamic context.

For instance, Cheng et al. (2010) examined performance in terms of effectiveness, efficiency and the learning effect of IR systems. This effort introduced system support for non-expert users to improve search performance over series of search sessions. User expectations (UE) as a measure has been explored. In Lamm et al. (2010), UE was assessed in relation to user-satisfaction using a confirmation and disconfirmation paradigm. In HCI, good "user experiences" are advocated with interactive systems during use. But, it is not yet clear the extent to which interaction experiences will lead to a successful IS product. van Schaik and Ling (2011) examined this in relation to technology acceptance. Performance was addressed with respect to "user experience" and equated to "interaction experience." Judging by the current level of IR systems' interactivity, subjective issues like user-satisfaction and user-system effectiveness need to be assessed. Palanisamy (2013) offered a conceptual model based on literature, with user satisfaction and usage as the success variable, and performance was characterized as "a good SE." In

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addition, system performances were considered with respect to users' experience and expectations, and user and system effectiveness in (e.g. Cheng et al. 2010; Lamm et al. 2010). But, none related them to communicate users' needs (or as users' requirements) for SEs development. Even, the dynamic nature of the Web context was ignored. In terms of context, our work is consistent with that of (e.g. Doll and Torkzadeh 1991 and Doll et al. 1994). In an end-user-computing environment (or context) like ours they measured user-satisfaction in a standalone data processing environment as specific application domain. But, ours differs as an interactive and dynamic context.

In IR, evaluative models are usually objective in nature, with a few that are subjective. This paper presents subjective evaluative models that its formulation includes the reflective approach that draws from psychology and cognitive research. This is because of the need for a baseline model; a model that relates its constructs as users' needs (or requirements). For instance, we require each constructs (or factors) to communicate users' needs as independently as possible. So, constructs' relationships must be in tandem with other contributing constructs. The intention is to have auxiliary theories that bridge the gap between abstract theoretical constructs and measurable empirical phenomena (Edwards and Bagozzi 2000; Jansen and Rieh 2010). Thus, only relationships between theoretical constructs are specified.

3.0 Web search engine and the changing environment

The WeSE is one example of an IR system. Like others (see Akhigbe 2012 for other examples of IR systems), the SE is a type of IS (Akhigbe et al. 2013; Palanisamy 2013). The start of the Internet helped IR to become increasingly relevant and researched. Now, on a daily basis over 80% of Web users use WeSEs (Jansen and Spink 2006; Sujatha and Dhavachelvan 2011), hence its adoption among the other IR systems in this paper. Some of the challenges identified in IR evaluative research are (i) what it means for IR systems to be successful, (ii) how to investigate users, their context, and (iii) how improved evaluations can be carried out.

Additionally, in IR, the scope of what is known as "system" includes elements of the retrieval context such as the user or the user's environment, which are often excluded in the evaluation of IR systems. Unlike the System-Centered (SC) approach, the User-Centered (UC) method takes into account the user, his/her context and situation, how satisfied they are, and their interactions with IR systems (Bilal and Boehm 2013). The UC approach has been developed to address a range of poorly understood issues relating to behavioural and cognitive aspects of the IR process. This human method is concerned with studying and evaluating the ways in which users choose terms for formulating, expanding or modifying their queries during a search process. It deals with models and issues that are cognitive and behavioural in nature that can affect not only the selection of search terms by users, but other further interactions with the system (Shiri et al. 2002).

The Web is highly dynamic (Langville and Meyer 2012), and a matter of great interest is how much the results of different SEs change over time. This gives a sense of how dynamic a search service is, either in its crawling policy, or through changes in its ranking computation (Webber 2010). Basically, WeSEs offer four main facilities, which include Web page gathering, clustering, the provision of hyperlinks, and they also allow users to issue queries. The benefits of these facilities range from users' ability to retrieve information, ability to connect Web pages, employ information retrieval algorithms to find the most relevant Web pages, to finding resources on the World Wide Web. Thus, the effective use of SEs for IR is a crucial challenge for any Internet user (Gordon and Pathak 1999; Liaw and Huang 2006). For WeSEs in particular, several studies exist based on the SC approach that investigate the usage or effectiveness of Web interaction on users' search for information. On the contrary, only few studies adopt the user-focused approach to evaluate the effects of SEs on individual information retrieval (e.g. Liaw and Huang 2003; Spink 2002, and Liaw and Huang 2006). Unfortunately, the SC methodology has remained dominant (Akhigbe et al. 2014), even though it can no longer cope with the challenge of evaluating the modern IR systems. This is due to their very interactive nature (Saracevic 1995; Dunlop 2000; Akhigbe et al. 2014). Exacerbating this is the fact that available works are mostly objective, thus gaps exists that require subjective approach (Clough and Sanderson 2013) to fill them up with respect to IR system evaluation.

The understanding of end-users' behavioural and cognitive attitudes toward SEs still remain a critical issue that cannot be overlooked (Liaw and Huang 2006). In Liaw and Huang's (2006) study this was pursued, and users' IR behaviours were investigated. The effort corroborates the understanding that users' SE experiences as attributes could be explored to understand their attitudes toward SEs. These experiences are harnessed as attributes in this paper to satisfy its goal.

3.1 Modelling user-centered attribute

People seek out and use information constantly as part of their daily life. This information often relates to work,

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leisure, health, money, and family. Additionally, a host of other topics can also be sought from a huge range of sources on the Internet using the WeSE (Johnstone et al. 2004). How users "seek out and use" information is believed in this paper to contain some form of characteristics that can be used to assess IS, with a bid to improving them. This is because users' requirements are believed to be locked up in such attitudes or form of characteristics. For instance, many studies in decision making, marketing and informatics have shown that people apply a rich context when seeking for information, making decisions, and forming opinions (Johnstone et al. 2004). This means that users construct sense and meaning that is appropriate to their context from the systems available to them from where they source information (Dervin and Nilan 1986, as cited in Johnstone et al. 2004). We therefore argue that how (or the way) users interact with information and their sources can be studied for evaluative purposes.

From the information processing theoretic view, the user-centered view of evaluation examines the roles humans play in translating received information into action. This may include judgement calls such as: Do I act on it? ... Ignore it? ... Pass it on? (Johnstone et al. 2004). As a result, users may develop behavioural habits when interacting with information that could either support or inhibit both the individual or organizational efficiency and effectiveness. These "rich evaluative resources" have been largely ignored by IS researchers (Johnstone et al. 2004). There is need to study the way people interact with digital information, which although requires a fundamentally different paradigm should not be neglected (Dervin and Nilan 1986, as cited in Johnstone et al. 2004). For such study, one question to ask is, what people do with the information they retrieve? The many options open to them may be human, process and context specific. Users may use them to update previous information, or they may store it, discard it, pass it on to someone else, combine it with other information, embed it in a report, and so on. These observable actions are collectively referred to as Human Information Behaviour (HIB). They form part of the overall phenomenon of human information processing. The totality of human information processing include internal cognitive processes, which do not necessarily result in observable behaviour.

Cognizance of this, we use the definition of some of HIB's proponents (e.g. Taylor 1991, and Davenport 1997, as cited in Johnstone et al. 2004) to influence user-centered attribute modelling. First, Taylor defined HIB as "the sum of activities through which information becomes useful." This view underscores the fact that an individual's information behaviour is dependent upon the type of person, the problem being resolved, the setting (of both people and problem) and what constitutes resolution of the problem. Secondly, for Davenport HIB has to do with "how individuals approach and handle information." This includes searching for it, using it, modifying it, sharing it, hoarding it, and even ignoring it. Consequently, when we manage information behaviour, we're attempting to improve the overall effectiveness of an organization's information environment through concerted action.

As earlier argued the traditional SC methodology cannot be used to realize this, hence the need to mature the alternate user-centered methodology for IS albeit for IR evaluative research. With this approach, this paper proposes that the "rich evaluative resources" or salient user-attributes in users' information behaviour can be harnessed for IS evaluative gain.

Therefore following the precepts of Johnstone et al. (2004), we also contend that a user-centered research paradigm that is constructivist among others can be used to study the process by which people interact with the information in their environment. To put this contention in proper perspective the Content, Context, and Process (CCP) framework is adapted. The CCP was used by Pettigrew (1985) and Symons (1991) to develop a parsimonious framework for building specific IS evaluation models. Its relevance in this paper is that its approach to evaluation allows for questions of what is being measured (Content), by whom and for what purpose (Context), to be asked. Additionally, guidance on the process of evaluation requires information to explain the *how* it will be undertaken (Symons 1991). Thus, the CCP's framework is extended in this paper to introduce both the measurement and the constructivist theoretics in the modelling of user-centered attributes or IS evaluation.

In order to properly integrate the CCP framework to model intended user-centered attributes in this paper, this paper draws from the two strongly identifiable themes that the IS evaluation literature has followed over time. The themes include (i) the development of evaluative models to measure identifiable constructs base on system use, and (ii) at a meta-level, the discussions on the paradigms that should be used to approach the evaluation process (Stockdale et al. 2008). Following (e.g. Stockdale et al. 2008) as inspired by (e.g. Pettigrew 1985, and Symons 1991, as cited in Stockdale et al. 2008), we use the CCP's framework rich vein of work to leverage the modelling of user-centered attributes in this paper. So, while Content and Context are used to capture the first theme, the second theme is captured within the Process part of the framework. This is because placed within an interpretive (or constructivist) paradigm as advocated in this research and by many IS evaluation researchers (Stockdale et al. 2008), a wide range of factors that need to be taken into account in an effective evaluation were easily recog-

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nized. For Stockdale et al. (2008), these factors are interlinked and cannot be considered in isolation. Therefore, how the evaluation is to be carried out and when the process should take place must be closely informed by what is being evaluated (the content). Additionally, the different perceptions of stakeholders must be included. In our opinion, since the proper identification of the stakeholders in an evaluation process is also important and it answers the question of the "who" perspective of the CCP framework, the purpose for the evaluation (the context) would hopefully be positively influenced. For more details of the CCP framework, its elaboration can be found in Stockdale et al. (2008).

4.0 Methodology

Here, we introduce the concept of user-centricity, the theoretical foundation, issues of scale development, data collection, data analysis and result, and sample profile as they apply in this paper.

4.1 The concept of user-centricity

The concept of user-centricity and its attendant methodology are the *sine qua non* of any science that models users' judgment of systems (Kelly 2009). This concept suggests the provision of the possibility of (evaluative researchers) being able to "step inside the head of the user" (Hotchkiss 2007). Thus, evaluating IS from this perspective could yield results that will assist stakeholders in toggling the perspective of users of a system (especially what motivates them to use the system) on and off. As a result, users' personas can be adapted as design vehicle (Hotchkiss 2007) to perfect the development of systems.

The end-result of using the concept can be used to assist stakeholders to stay on track and remain in the mindset of the user during system design. In a nutshell this means treating the user as king, and making everything (deign-implementation-evaluation, and re-design if needful) revolve round the user. In all the sense of it, the user being king hypothetically connotes building everything about a system around the user. This is very important in order to deliver the best possible end-user experiences that are defined in users' own terms. This is far from the "corporate feel good thing," but from the "user feel good" perspective (Hotchkiss 2007). Like Patton (2007) puts it, in the absence of a strong mental model of specific users, we self-substitute. Self-substitution isn't user-centric – it's self-centric. Therefore, expressing concern for users without understanding them, leads to self-centric evaluation." With this concept, this paper uses the theoretical foundations described in Section 4.2 to influence the modelling of the attributes of users. This is towards the development of a baseline Second-order Measurement Model (SoMM) for IR system evaluation. The SoMM (see Figure 2) is an extension of the First-order Measurement Model (FoMM) (see Figure 1) proposed in Akhigbe et al. (2014). The motivation for the SoMM is stemmed from the desire for a more valid and reliable user-centric evaluative model.

4.2 Theoretical foundations

The theory of measurement suggests the use of multiple-items to measure constructs; thus providing sufficient theoretical grounding to avoid the use of single-items (Furr and Bacharach 2007; Viswanathan 2005, as cited by Kelly 2009). It supports response reliability and validity, and allows studies (like this one) to move evaluative exercise from being "monolithic to pluralist notions" (Babaheidari 2009). Notions are a representation of subjects' normal experiences from system use. This was modelled using users "judgments," and only users of any three WebSE formed the sample stratified for the study. This was necessary to recognize every subjects' previous search experiences and search norms.

Based on the goal of this paper, the Measurement Theory (MT) is axiomatically presented using mathematical operations. These operations draw from the representational, classical as well as the conjoint view of the theory of measurement. Their adoption is based on the fact that the views (see Trendler 2009) underscore the measurement theoretics. This is because they concur with the understanding that measurability is empirical. That is the attribute involved in measurement are really quantitative (Trendler 2009). Cognizant of this, the constituents of an Empirical Relational System (ERS) is adapted to interpret the MT since it has its roots in the theory of models as developed by (Tarski 1954, as cited in Trendler 2009).

The MT when conceptualized as an ERS can be formally specified as a finite set of elements called the domain of the relational system say A, and relations between the elements (Trendler 2009). Formally $A = (A, R_1, \ldots, R_n, O_1, \ldots, O_m)$;

Where A is an ordered tuple, such that;

$$A = a\ nonempty\ set\ of\ objects;$$
$$R_i = i\ set\ of\ relations\ on\ A \ni i = 1,\ldots,n;\ and$$
$$O_j = closed\ binary\ operations \ni j = 1,\ldots,m.$$

Following the MT concept of (e.g. Michell 1990 and 1997, as cited in Trendler 2009; Briand et al. 1996, and Ishikawa 2007, 2006) we define measurement as being a

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homomorphism (see Ishikawa 2006; and Trendler 2009 and other related works) between empirical and numerical structures. This allowed us to interpret the ERS as a relational system. This is such that the elements are assumed as magnitudes of a quantity and the relations between the elements are relations between magnitudes. This is important for us to obtain the expected a quantitative structure. Thus, equal levels of "some manifest variable" that necessarily correspond to equal levels of "some latent variable" are not taken for granted (Trendler 2009). Consistent with what is suggested in Trendler (2009), there is need for this to be ascertained by an experiment, which is described and its result presented in this paper. Based on these theoretics, it was therefore possible to use MT's suggestion that the use of multiple items (observables) to measure attributes (unobservables) are better than the use of single items (Kelly 2009). Readers can consult (e.g. Furr and Bacharach 2007; Viswanathan 2005; Kelly 2009) for details on this.

Basically, constructivism is the belief in pluralistic, interpretive, open-ended, and contextualized perspectives toward reality. It includes notions of aspects that; (i) there is a real world that sets boundaries (or context) to what we can experience, and (ii) reality is local and there are multiple realities or pluralistic perspective (Creswell and Miller 2000). For instance, users' experiences are active processes in which users' actively construct ideas (or concepts) based upon their "current or past knowledge" of system use. Additionally, of the cognitive and social views of constructivism (Talja et al. 2005), we adopt the cognitive view. This is because we believe that individuals create knowledge structures and mental models through their interactive experiences with (and observation of) the system during use. Unlike social constructivism, Cognitive Constructivism (Cog-C) lay major emphasis on the way in which knowledge is actively built up by the cognising subject. Thus, the individual mind can serve both individual and organisational internal and external reality (Talja et al. 2005).

To avoid the issue of individualism, which is the focus of the Cog-C view, we also draw from the strength of Collectivism, which focus is on domains that form their contexts for information behaviour (what users do with information when they have it) and knowledge organisation. But, the Cog-C takes individual searchers and their interaction with IR systems as its research object. It also takes the view that work tasks provide the primary context for information behaviour (Talja et al. 2005). The adoption of the Collectivist view to strengthen the aspect of "Context" with respect to individualism is informed by the understanding that (i) both Cog-C and Collectivism find applicability as orientation strategies in IS, and (ii) they clearly complement each other (Talja et al. 2005). The theory of constructivism seeks to contribute to the realization of user requirements' elicitation. This is poised towards improving not only user interfaces, but user-system interactivity. For the theory of collectivism, it is used to underpin and orient this work towards information practices and knowledge organisation in the specific context of the Web environment that is highly dynamic. With respect to the theory of measurement, it is hoped that the proposed model will be empirically feasible and substantially quantitative (Scott and Suppes 1958). This is consistent with literature in terms of the desire to satisfy the need for using metatheories, since they serve as orientation strategies and are broader and all-encompassing than unit theories (Vakkari 1997, as cited in Talja et al. 2005).

With these postulations ordinal data was collected from users' perspective based on their interactive experiences. The assumption accommodated was that users possess specific familiarity with the system as a result of their interactive experiences. Thus, we assumed that they can project how the system should be perceived, and as such data elicited from them will hopefully be a rich resource to develop the evaluative model intended in this research. Following Bertini et al. (2013), and Morkos and Summers (2013), users' requirements for WeSEs were obtained from users. Information about the model developed, the data used and the sample adopted are presented next in the following sections.

4.3 Scale development, data collection and sample profile

Following user-related research efforts of (e.g. Borlund and Ingwersen 1997; Shiri et al. 2004; Yang et al. 2005; Ong et al. 2009; Sumak et al. 2011), data were collected using the questionnaire survey technique. This happened within the space of six months using twenty-one (21) decision variables in a longitudinal experiment, which result is presented in this paper. The systematic random sampling technique, which allowed each users to have equal chances of involvement was employed. Ordinal data were therefore elicited from a non-simulated work task situation that involved 250 real end users as test persons using a 5-point Likert scale of 1 (strongly agree) to 5 (strongly disagree) interpretation. It was assumed that the 250 respondents had been involved with the use of WeSEs. As such, they have experienced users' pre-task (conceptualized and thought out their IN), post-task (had used any three WeSEs in attempt to satisfy their IN), and post-system usage (had used the information gotten, and are satisfied or unimpressed with the system). The demographic variables used in the experiment include age, sex, status, and surfing experiences. This presentation is consistent with (e.g. Yang et al. 2005; Sumak et al. 2011), and

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the details of these demographics are presented in tabular form for easy sense making (see Table 1).

4.4 Data analysis and result

This section describes the analysis and results for the two levels of the models intended in this paper. The exploratory aspect of the FA was use to obtain the required a priori factor structure – the FoMM (see Figure 1 and Tables 1 and 2).

Following Yang et al. (2005), the FoMM was specified to include four identified first-order factors that are correlated. Initially we were interested in factors with reasonable validity and reliability considering the goal of the paper. Thus, every observed variables with nonzero loading and measurement error terms were excluded. The reliability and validity of FoMM were tested using the CR and AVE (see Table 3 for meaning) parameters respectively.

Researchers in IS have foretell the possibility of an advanced measurement model, if there exists a FoMM (Parasuraman et al. 1988; Yang et al. 2005). Thus, an attempt was made to reconsider the FoMM with the aim of establishing such possibility. The need for an advanced FoMM or a SoMM was informed by the need to demonstrate a superior evaluative measurement model. This was meant to underscore the assumption that better users' requirement could be consequently realized. Hence, a SoMM that imposes a structure on the pattern of correlations among the first-order factors that consequently generate a more parsimonious baseline evaluative or measurement mode is presented (see Figure 2).

Also, consistent with what is obtained in literature (Kumar and Dillon 1990), we demonstrate that a particular factor analytic model can ultimately determine the meaning and estimation of reliability and validity of the factors of the model. In other words, reliability and validity estimates

Dem Var.	**Age range**	**Sex**
Var.Desc.	16-25; 26-35; 36-45; 46-55; 56 & above	F; M
%	17 27 48 5 3	22 78
Dem Var.	**Status**	**Surfing experience**
Var.Desc.	Student.; Worker.; Researcher; Lecturer	Daily; Weekly; Monthly; Never
%	22 41 14 23	73 21 6 0

Table 1. Demographics sample size characteristics
DemVar. (Demographic Variable); **Var.Desc.** (Variable Description); **%** (Percentage showing freq. of occurrence); **F** (Female); **M** (Male);

Items	i1	i2	i3	i4	i5	i6	i7	i8	i9	i10
Ldgs	0.75	0.67	0.57	0.75	0.69	0.66	0.68	0.66	0.67	0.70
Items	i11	i12	i13	i14	i15	i16	i17	i18	i19	i20
Ldgs	0.65	0.77	0.69	0.65	0.66	0.65	0.58	0.60	0.55	0.67

Table 2. Result of Data Analysis for EFA Loadings.
*** Cut off of** ≥ 0.45; Ldgs (Loadings), EFA (Exploratory Factor Analysis)

Factors	**CR**	**AVE**
Interactivity	0.65	0.56
Usability	0.87	0.54
Interfaces architecture	0.84	0.51
Content	0.71	0.65

Table 3. Result of CFA test of FoMM Loadings.
CR (Composite Reliability); **AVE (**Average Variance Extracted)

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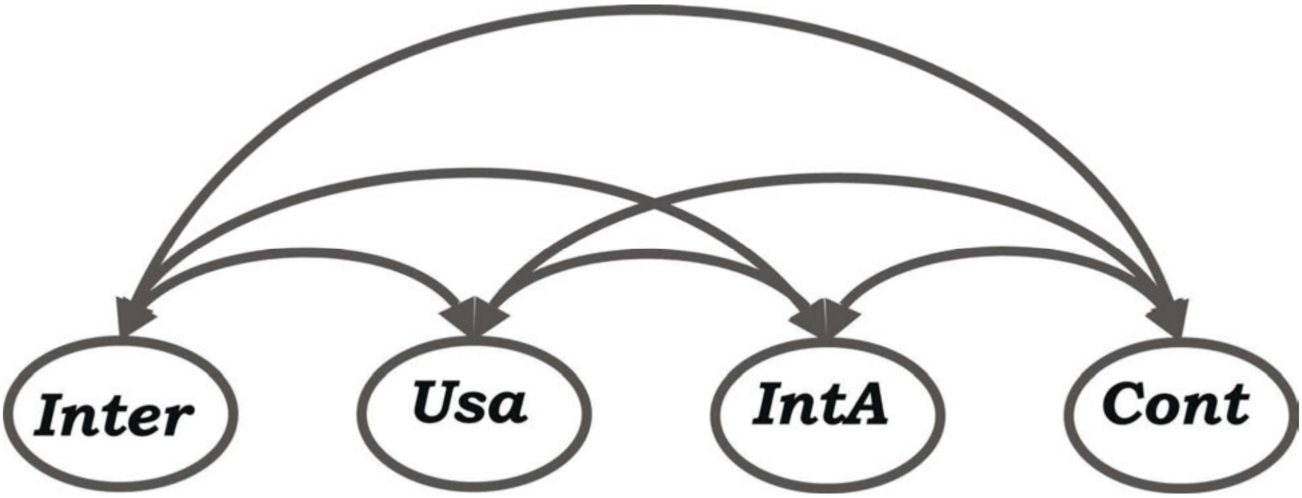

Figure 1. First-order Measurement Model (**FoMM**).
Interactivity *(Inter)*, Usability *(Usa.)*, Interface Architecture *(IntA.)*, and Content *(Cont.)*
SEM result for FoMM (x^2/d.f. = 2.55; GFI = 0.10, NFI = 0.099, CFI = 0.085, NNFI = 0.097, RMSR = 0.034, RMSEA = 0.069.

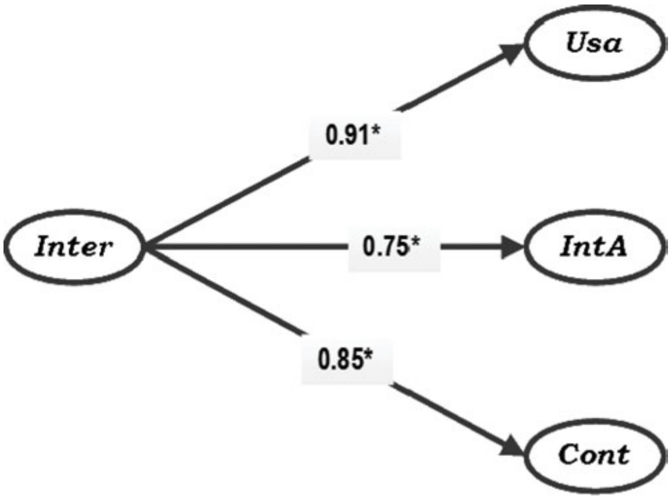

Figure 2. Second-order Measurement Model
SEM result for SoMM (x^2/d.f. = 2.52; GFI = 0.11, NFI = 0.10, CFI = 0.088, NNFI = 0.098, RMSR = 0.032, RMSEA = 0.067), & Value with * are CFA value.

differ depending on the specification of the factor analytic model. Hence, the choice of a particular factor analytic measurement model is not an innocuous decision (Kumar and Dillon 1990). Thus, the models (e.g. FoMM and SoMM) presented are illustrative of degrees of reliability and validity. This means that the SoMM is illustrative of a more parsimonious approach to relating users' needs as requirement for the development of IR systems.

Nevertheless, how to foretell the aforestated possibility of a SoMM was not made clear in literature. We therefore postulate that a sense of this could emanate starting from findings in the sample size characteristics of the users' population that took part in the survey experiment. For instance, in Table 1 the surfing experiences of the users of the WeSEs that was surveyed showed that 73% of the total sample population size use SEs on the Web on a daily basis. This is very close in consistency with an earlier claim (see Sullivan 2003; Jansen and Spink 2006; Jansen and Molina 2006) that 80% of those who browse the Internet use one type of SE or the other. This prompted the desire to find out if a SoMM really existed. From Table 1, it is also obvious that the interactivity factor fared better than others even with the slightest measure. This prompted the initiative to consider loading it on other factors. The result showed that the FoMM demonstrated less reliability and validity as compared to SoMM (see Figure 2) when interactivity is loaded against the other three factors (see Figure 2).

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5.0 Proposed models

There was need to revise the FoMM to achieve the SoMM because the factors of the FoMM were meant to communicate the requirements of users of WeSEs. Consistent with (e.g. Wu et al. 2008) and from within IS and IR literature items (see Table 2) were adopted from previously published scales. In Akhigbe et al. (2014) the dynamic and fluxing nature of the Web (Jensen 2006; Webber 2010) as earlier argued necessitated the need for the FoMM in Figure 1. This motivation remain the rationale for the SoMM. This is because of the overarching need for a better model from where users' needs as requirements can be communicated. In the FoMM a model with Baseline Criteria (BaCrit) was formulated. The benchmarks represent users' needs against which users' needs as their requirements can be continuously compared. Thus, as proposed in (e.g. Bertini et al. 2013) the technique of conceptualization as is in qualitative evaluative methodology was engaged to translate the BaCrit of the FoMM. These BaCrit allowed users' judgments to be translated into their requirements (see Figure 3). This is because they are the outcome of the data analysis carried out using the FAs.

Hopefully, the SoMM and its constructs are expected to satisfy the need for baseline criteria or users' needs as requirements. The motivation is to put in the hands of users the influence of navigating and harnessing the Web using SEs. The baseline properties (or qualities/attributes) of the FoMM and SoMM are founded in the inferential statistics – FA used in the paper. The replicability, and the degree of validity of the models contribute excel-

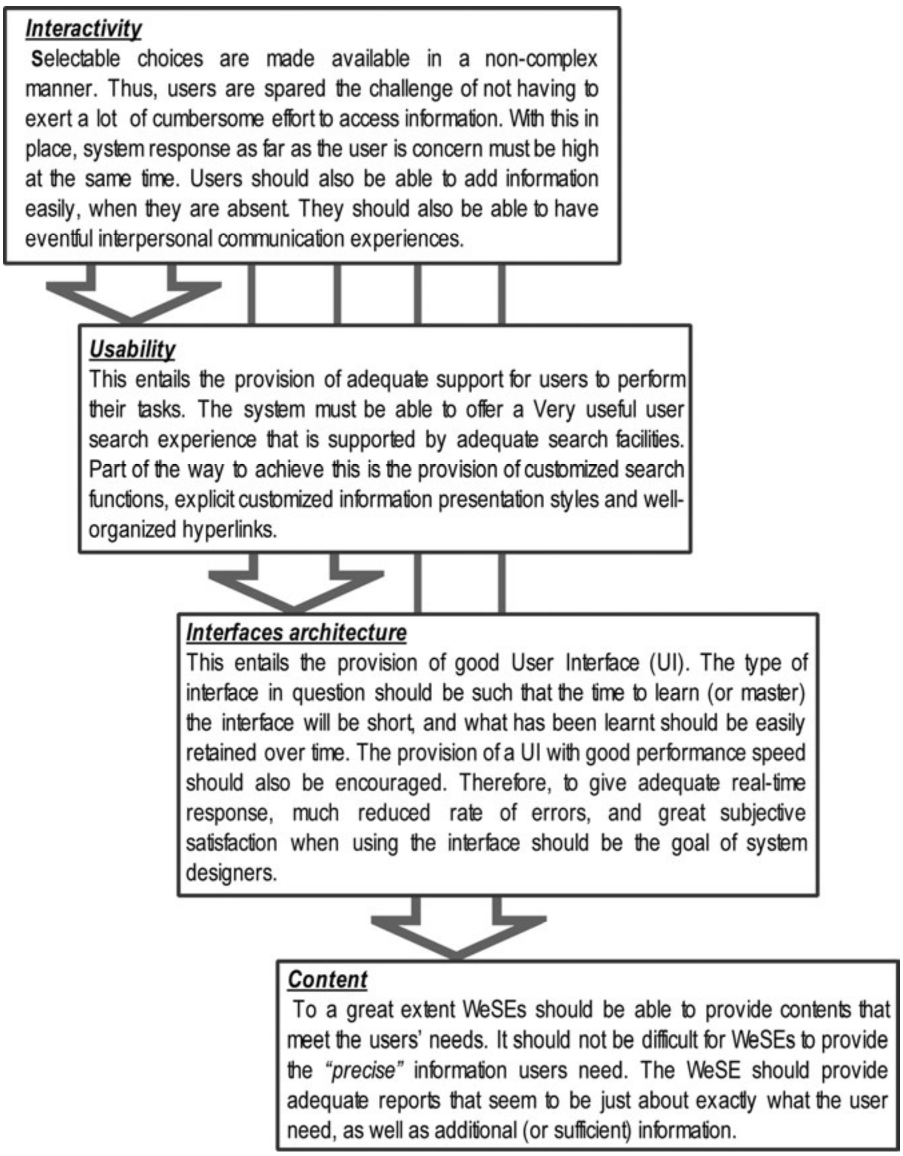

Figure 3. Baseline Criteria in its Conceptualized form based on the SoMM

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lently to the models' baseline properties. This is demonstrated by the Structural Equation Modelling (SEM) results that is meant to establish further degree of validity and reliability. These results are presented under Figures 1 and 2. These models (at whatever level users' need to use them) are extendable. With this unique property (i) the ability to accept new criteria (attributes) – factors as the need will arise due to the impacts the changing nature of the Web will make on the SEs, and (ii) the ability of the models not to be out-of-date or obsolete is guaranteed. Usually, system requirements are expected to reflect stakeholders' needs, and also "describe system's externally-perceived functionality as well as certain properties at the desired granularity" (Soffer and Dori 2013).

For instance, Interactivity, Usability, Interfaces architecture, and Content are user-centric attributes. This is what users' experience and expectation, and users' and system effectiveness are hinged on (Cheng et al. 2006; Lamm et al. 2010; Chen and Pu 2010). They are therefore indispensable at projecting users' needs as requirements for systems.

6.0 Conclusion

The novelty demonstrated in this paper is underscored by the findings (see the section on literature review) that previous studies did not consider how to relate IS's evaluative results as users' needs. They excluded from their evaluative intentions the important aspect of communicating users' needs as their requirements for WeSEs development particularly from the perspective of a dynamic context (or environment). This is rather unfortunate as well as enigmatic. This therefore emphasizes the fact that the user-centered methodology has continued to remain unpopular, unlike the system-centered evaluative methodology. This lack of popularity is quite visible with respect to the formulation of evaluative models, which evaluative results can encapsulate users' need(s) such that they relate (or specify) them as users' requirement. This was the premise on which the initial work from which this paper builds from employed the user-centered approach to develop a user-centered evaluative FoMM (Akhigbe et al. 2014).

In this paper the FoMM (see Figure 1) was revised and an advanced version known as the SoMM (see Figure 2) was developed from it base on the rationale presented earlier on in this paper. The model's qualities (see Figures 2 and 3) (attributes or criteria, which are evaluative results) was used to relate users' needs as requirement for WeSEs development. The motivation to communicate users' needs as users' requirement is underscored by the belief we share with Bouch et al. (2000), and Akhigbe et al. (2014). That is, the success of any WeSE in the delivery of desirable levels of assistance to users (e.g. in the future), especially in a dynamic context must be based, not only on the progress of technology, but also on users' requirements, which must be regularly re-examined.

The result of the test of the SoMM using the SEM technique of the FA showed better validity and reliability when compared to that of the FoMM. For instance, the SEM result for the SoMM is (x^2/d.f. = 2.52; GFI = 0.11, NFI = 0.10, CFI = 0.088, NNFI = 0.098, RMSR = 0.032, RMSEA = 0.067), and that of the FoMM is (x^2/d.f. = 2.55; GFI = 0.10, NFI = 0.099, CFI = 0.085, NNFI = 0.097, RMSR = 0.034, RMSEA = 0.069). When compared to the recommended value, which is (x^2/d.f. $\leq$ 3.00; GFI $\geq$ 0.9, NFI $\geq$ 0.9, CFI $\geq$ 0.9, NNFI $\geq$ 0.9, RMSR $\leq$ 0.05, RMSEA $\leq$ 0.08) (see Wu et al. 2008), the superiority of the SoMM over the FoMM is evidently quite illustrative.

Hopefully, based on the aforementioned statistical results, the baseline criteria raised and presented using the SoMM as a build up from the FoMM when implemented should inform better WeSEs development. Therefore, the resultant WeSE(s) should do better. This can be gauged in terms of how they would (i) assists users to cope with the unpredicted and changing environment (context) of the Web, (ii) support users to have fulfilled user experiences when using WeSEs, (iii) assists users in locating documents that contain information that satisfies their IN to unimaginable extent, and (iv) give enhance user experience, expectation, and provide system effectiveness. This means stakeholders and investors with particular interest in e-Commerce, and those in pursuit of better knowledge organization tool(s) would find the models useful in the investigation of users' requirement for WeSEs.

Aside from the stated implications of this paper in the previous paragraph, this paper's contributions include that: (i) the FoMM and SoMM should become a norm in the investigation of users' requirement, not for WeSEs alone, but for other IR systems. This is consequent upon the degree of reliability the FoMM and the SoMM demonstrated, which can principally be attributed to the statistical model employed in their formulation, (ii) interactivity should be studied and treated in WeSEs' development as the vortex of IR (Ingwersen and Jarvelin 2007), and (iii) interactivity should be investigated as a subjective variable that is influenced by several factors even more than the ones considered in the formulation of the SoMM (see Figures 2 and 3). The extent to which there is mapping between objective and subjective quality of service delivery by WeSE, and the contextual factors that can influence users' ability to cope with information seeking and searching shall be rigorously pursued in the future. With respect to the Web-based environment and its dynamic context these issues have not been investigated.

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Appendix A: ***(Measurement Scale)***

Find below the 20 outstanding items of the 21 items presented in the experiment (the item with *** was removed during EFA)

1. Selectivity or complexity of choice
2. Users exert less effort to access information
3. Responsiveness to the user
4. Monitoring of information use
5. The ease of adding information by user
6. Facilitation of interpersonal communication
7. Supports me to perform my tasks
8. The search facilities are adequate
9. Customized search functions
10. The system provides the precise information I need***
11. Customized information presentation
12. Well-organized hyperlinks
13. Time to learn
14. Retention over time
15. Speed of performance
16. Real-time response
17. Rate of errors by users
18. Subjective satisfaction
19. The system content meet my needs
20. It provides reports that seem to be what I need
21. The system provides sufficient information

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