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Creativity in Digital Libraries and Information Retrieval Environments

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Abstract. Inspired by Weisberg's [20] argument that creativity exists in everyone and on the assumption that every information seeker is creative and undergoes a creative process in information seeking, this paper synthesizes a holistic "creativity" model and "information seeking" model to identify stages in a creative process for information seeking. A pilot study was conducted to verify these stages and also examine if present digital libraries and information retrieval environments provide "creative" features to support creative information seeking. We discussed these initial findings and made recommendations for further work to better support creative information seeking in digital libraries and information retrieval environments.

1 Introduction

Most information retrieval (IR) systems are designed to judge precision and recall of documents based on a match between index and query terms. However, precision and recall measures are limited, as they do not consider the contextual nature of human judgment. Measures of precision and recall should take into account that relevance is influenced by the knowledge state and intentions of the user [3], implying that relevance judgment is subjective. Moreover, since everyone has creative traits as argued by Weisberg [20], it can be inferred that the extent of creativity in a person influences his/her judgment of relevancy. If creativity is built on past experiences, then a creative person's judgment of relevancy will also be affected. In other words, if a person's past experience shows that some sources are not useful, he/she may judge documents from these sources as irrelevant and hence likely not use them in his/her creative process for information seeking.

Our study is inspired by Weisberg's [20] argument that creativity exists in everyone and results from ordinary thinking. Ordinary thinking is a continuity of the past. Individuals deal with new situations based on what has been done in similar situations. However, it must not be misunderstood that works based on past experiences have no novelty. Based on this theory, we make the assumption that *every information seeker is creative and undergoes a creative process in information seeking*.

This paper, therefore, attempts to establish a relationship between "creativity" and "information seeking". Establishing such a relationship is important as it provides a different perspective of information seeking leading to new and perhaps improved ways of developing interfaces for supporting information retrieval. Such a perspective sees a creative process as inherent in information seeking and may therefore improve query formulation and refinement, searching, browsing, and filtering, thereby, helping

users better meet their information needs. Sections 2.1 and 2.2 survey “creativity” models and “information seeking” models respectively to provide a basis for developing stages in a creative process for information seeking in Section 3, resulting in a set of design features for supporting creativity in digital libraries (DLs) and information retrieval environments (IREs). A pilot study was then conducted to address two objectives: (1) to verify the stages in a creative process for information seeking and (2) to examine if ACM Digital Library and EI Engineering Village 2, examples of DLs and IREs respectively, have implemented “creative” features to support users’ creative process for information seeking.

2 Creativity and Information Seeking

2.1 Survey of Creativity Models

Creativity means different things to different people. One definition associates it with the genius. Weisberg [20] highlights that attempts to understand creativity in our society is largely dominated by the “genius” view, which associates creative achievements as a result of great individuals using extraordinary processes. However, he argues that creativity is a trait that everyone has and that novelty results from the use of similar thinking processes when a particular person is put in a particular environment. He emphasizes that his argument is not trying to claim that great individuals who produce great original works are the same as ordinary individuals but that the thinking processes used are similar. Other definitions of creativity associate it with process-oriented or product-oriented views. Process-oriented definition highlights creativity as a process that results in innovative, novel products [7, 12]. Product-oriented views associate creativity to the attributes of the outcome. Only when an outcome is both novel and valuable can creativity be said to have happened [1].

Synthesizing the different views for creativity, we define attributes of a holistic model of creativity focusing on the four fundamental aspects of a creative person, process, product, and environment [17, 18, 20]:

- Attribute #1 - Creative Person. The creative person should have imagination, independence, and divergent thinking ability [5]. The ability to think ‘holistically’ is a key feature. It is vital to help a person break away from conventional ideas when one faces a dead end. King and Pope [13] also associate the creative person with psychological richness, complexity, and openness to experience.
- Attribute #2 - Creative Process. The creative process can be broken down into four stages [11]:
 1. *Preparation.* The individual gets interested in the problem and collects all necessary data needed.
 2. *Incubation.* The individual unconsciously works on the problem.
 3. *Illumination.* Possible ideas start to surface to consciousness.
 4. *Verification.* The idea is worked into a communicable form.
- Attribute #3 - Creative Product. A creative product satisfies two properties: novelty and value [1, 10, 20]. Novelty is determined by a comparison of the new product with existing ones [1, 10]. Value is concerned with the relevance of the product to human purposes [1]. Amabile [2] explains that judgment of a creative product is dependant on a group of appropriate observers.

- Attribute #4 - Creative Environment. A creative environment's characteristics include boldness, courage, freedom, spontaneity, clarity, and self-acceptance [16]. The environment should support collaboration since idea generation and creativity do not occur in isolation [6, 15].

2.2 Survey of Information Seeking Models

To help us establish a mapping between “creativity” models and “information seeking” models, we briefly revisit some established information seeking models. Taylor's [19] model focuses on the importance of negotiation interaction between the inquirer and librarian so that information needs can be addressed. On the other hand, the Sense Making Model focuses on how individuals use observations of others as their own to construct pictures of reality and use these pictures to guide their search behavior [4]. Wilson's [21] model focuses primarily on how information needs arise, context of the information as well as barriers that may prevent the actual search for information. Other models focus specifically on the activities and behaviors characteristic in information seeking. Kuhlthau's [14] model concerns the feelings, thoughts, and actions associated with different stages of the “information search process”.

In this paper, we make use of the behavioral model of information seeking as postulated by Ellis [8] and Ellis, Cox and Hall [9] as it takes into account the subjective sequence of information seeking behavior/activities, which varies according to the context and circumstances of the seeker at that point of time. In addition, it also focuses specifically on the activities in information seeking. Using this model, the information seeker undergoes eight generic activities [8, 9]:

- Activity #1 - Starting: This refers to activities characteristic of the initial search for information on a new topic or area. The seeker may have some or no familiarity with the topic or area. Activities when starting on a new topic include asking colleagues, consulting literature reviews, catalogues, abstracts, and indexes.
- Activity #2 - Chaining: This refers to following chains of citation connections between materials, which can be forward chaining and backward chaining. Forward chaining involves the use of citation indexes or bibliographic tools to identify citations to relevant materials. Backward chaining refers to following up references cited in materials consulted.
- Activity #3 - Browsing: Semi-structured or semi-directed searching in an area of potential interest. Activities in this stage include browsing table of contents of journals, checking sources available in the library, browsing along shelves, and using the “browse” and “search” features of IR systems.
- Activity #4 - Differentiating: Using characteristics/differences in information sources to filter the amount of information obtained. Some characteristics for filtering include topic of study, creditability, author, type of source, and language.
- Activity #5 - Monitoring: Maintaining awareness of developments in a field through regular monitoring of particular sources. Methods that information seekers use to monitor sources include the use of informal contacts, monitoring services, research directories, and journals and publishers' catalogues.
- Activity #6 - Extracting: Systemically working through a particular source to locate materials of interest. This activity requires the seeker to set aside substantial

amount of time to go through sources, like journals, books, computer databases, and indexes to locate information of interest. This activity is most directed among all information seeking activities.

- Activity #7 - Verifying: This involves checking the accuracy of information.
- Activity #8 - Ending: Activities characteristic of information seeking found at the end of a topic or project, for example, during the preparation of papers for publication.

3 Stages and Design Features for Creative Information Seeking

In Section 3.1, we establish and present a proposed mapping between a holistic creativity model and an established information seeking model. Section 3.2 identifies potential design features to foster a creativity process for information seeking. Section 3.3 draws up and develops stages in a creative process for information seeking and design features to support creative information seeking in DLs and IREs.

3.1 Establishing Mappings Between “Creativity” and “Information Seeking”

A walkthrough of the “creative process” (as discussed in Attribute #2, Section 2.1) and the “information seeking activities” (as discussed in Activities #1- #8, Section 2.2) revealed four common links between the two models. We synthesized and organized these common links to reflect the *creative process in information seeking* and they are presented as follows:

- Link #1. Preparation in the “creative process” is concerned with collecting all necessary information to facilitate creativity. Thus, this stage can be linked to starting, chaining, and browsing in “information seeking” (see Activities #1, #2, #3; Section 2.2) as these behaviors are also concerned with collecting information.
- Link #2. Incubation as described in the “creativity process” involves unconsciously solving the problem. This means that the creative person is unconsciously trying to make linkages among information and some sort of filtering must occur to facilitate the linking process. Hence, incubation can be mapped to differentiating in “information seeking” (see Activity #4; Section 2.2).
- Link #3. Illumination happens when an idea strikes. The possible information seeking behaviors that facilitate this process include monitoring developments and extracting relevant information from information sources (see Activity #5, #6; Section 2.2), which also relates to illumination in the “creativity process”.
- Link #4. This stage involves working the idea into a communicable form. Checking accuracy of information takes place before the idea is worked into such a format. Thus, verification in creativity is linked to verification behavior in information seeking (see Activity #7; Section 2.2).

The common links identified between the “creativity process” and the “information seeking activities” provide a basis for identifying stages in creative information seeking. Hence hereinafter, we would rename these links to describe “stages” in a creative process for information seeking.

3.2 Identifying Stages in Creative Information Seeking and Its Design Features

Having established the common links/stages between the “creativity process” and the “information seeking activities”, we then brainstormed on a set of design features

together with information specialists that might foster creativity in DLs and IREs. Design features that might foster each stage (as highlighted in Section 3.1) between “creativity” and “information seeking” are described as follows:

- Stage #1. Features here should assist users to acquire information to begin the creative process. Such features are: search / browse, iterative searching, relevance feedback, customization and personalization, cross-referencing, subject classification, and query refinement. It is also important for DLs and IREs to clearly state sources available and its domain of focus. Other value-adding features include: collaboration, encouraging learning from mistakes, and providing rewards and praise.
- Stage #2. Features that help users reduce information and make connections between materials are: collaboration with domain experts, providing sources from different domains, relevance feedback, and filtering criteria. Incubation can be long and frustrating. Features that help make the process pleasant would be: encouraging learning from mistakes, providing rewards and praise, showing interest in helping users, providing system usability, offering learning opportunities, and allowing users to stop and begin searching.
- Stage #3. Features that foster monitoring and extracting for idea discovery could be: collaboration, current awareness searching and profile, subject classification, and relevance feedback. Features should motivate and encourage users towards illumination. They could be: encouraging learning from mistakes, providing rewards and praise, showing interest in helping users, providing system usability, offering learning opportunities, and guiding users from novices to experts.
- Stage #4. Features that facilitate verification would include: iteration of search process; relevance feedback; providing collaboration and contacts among subject experts, and search / browse. Value-adding features to enhance usability include: encouraging learning from mistakes; guiding users to move from novices to experts; providing rewards and praise, and system evaluation/feedback.

3.3 Establishing Stages in a Creative Information Seeking Process

A further examination of the features described in Section 3.2 to foster stages in a creative process for information seeking showed that repetitions existed among features in the different stages. This was because too many information seeking behaviors were grouped to each creative stage. For example, in Stage #1, preparation in a creative process was linked with starting, chaining, and browsing activities in information seeking (see Stage #1; Section 3.1). Thus, the stages were refined. This time, a stage was established only when there was an obvious similarity between stages in a creative process (see Attribute #2; Section 2.1) and activities in information seeking (see Activities #1-#8; Section 2.2). Otherwise, concepts were kept separate. In other words, in Stage #1, preparation in a creative process (see Attribute #2; Section 2.1) could only be mapped to starting in information seeking activities (see Activity #1; Section 2.2) since both were concerned with commencing. Chaining and browsing in information seeking (see Activity #2 and #3; Section 2.2) should be kept separate, as they were not related to preparation in creative process.

This new set of mappings created the revised six stages in a creative process for information seeking. Terminology used for these stages were derived from creativity

and information seeking models and hence grounded in these models. A final set of design features to foster each stage was iteratively refined and is presented as follows:

- Stage #1 - Preparation for starting information seeking. Features here focus on how the DLs and IREs prepare users for information seeking and how DLs and IREs prepare themselves for information seeking. The basis for this stage and features came from Stage #1 (Sections 3.1 and 3.2). These features could be: customization and personalization according to creative/information seeking ability, offering learning activities to enhance creativity, showing interest in helping users achieve need, and stating the domain focus of its sources.
- Stage #2 - Chaining information sources. Features included here are: cross-referencing within system, subject classification to help users obtain sources on a particular topic, and offering a variety of sources from various domains. These features help users find / track related materials. The rationale behind this stage and features were derived from Stage #1 (Sections 3.1 and 3.2).
- Stage #3 - Browsing and searching. This stage and its features are grounded in Stage #1 (Sections 3.1 and 3.2). Features here are concerned with facilitating browsing and searching so that sufficient information is acquired to support incubation and illumination. Such features would be: providing clear structured ways of searching, guiding users to move from novices to experts, mapping design features to information seeking, query formulation, browse / search features, relevance feedback, and search iteration.
- Stage #4 - Incubation for differentiating purposes. This stage is concerned with unconsciously filtering information and establishing linkages. Supportive features included are: encouraging learning from mistakes, providing reward and praise, filtering criteria, offering access to subject experts, and allowing users to stop and continue information seeking at any time. The formulation of this stage and its supportive features were derived from Stage #2 discussed in Sections 3.1 and 3.2.
- Stage #5 - Monitoring and extracting for illumination. The foundation for this stage and its features are provided by Stage #3 (Sections 3.1 and 3.2). Monitoring developments in a field and extracting relevant information are essential for illumination. Facilitating features could be: collaboration to enhance creativity, and providing current awareness search and profile.
- Stage #6 - Verification of information sources. After illumination, it is important that ideas are verified and worked into a communicable form. Features that support these processes are: providing contacts of subject experts/authors for verification as well as evaluation features to verify system uncertainties and for designers to improve the system. The rationale for this stage and features arose from Stage #4 in sections 3.1 and 3.2.

4 Pilot Study

A pilot study was conducted to fulfill 2 objectives:

- (1) To verify the stages in a creative process for information seeking; and
- (2) To examine whether ACM Digital Library and EI Engineering Village 2, examples of DLs and IREs respectively, have implemented design features (as discussed in Section 3.3) to support users' creative process for information seeking.

Subjects and Selected Digital Library / Information Retrieval Environment

The six subjects (denoted as S1-S6) selected were post-graduate research students: three 2nd-year PhD students and three 2nd-year Masters students. Three subjects were from the Communications Division and others were from the Information Studies Division in the School of Communication and Information (Nanyang Technological University). All subjects had experience using DLs and IREs. These subjects were divided into two groups. Group 1 (S1-S3) was asked to find an article using a digital library (DL), ACM Digital Library (ACMDL; see <http://www.acmdl.org>). Group 2 (S4-S6) was asked to find another article using an information retrieval environment (IRE), EI Engineering Village 2 (EV2; see <http://www.engineeringvillage2.org>). ACMDL and EV2 were chosen, as they were among the most commonly used DLs and IREs, after consultation with information specialists.

Protocol for Objective 1

Subjects were asked to solve an information need related to vocabulary problems in information retrieval using their respective DL and IRE. S1-S3 were first briefed on ACMDL and S4-S6 were briefed on EV2. Then they were provided a search query, which they used to find a specified article related to the information need. Subjects could use the query provided or added more terms to the query. After they have found the article, they noted the steps taken in a form provided.

Protocol for Objective 2

We did a walkthrough of ACMDL and EV2 based on the proposed design features (as discussed in Section 3.3) that might foster creative information seeking. For each proposed design feature, implemented features in ACMDL and EV2 that satisfied the proposed one were noted.

5 Findings and Analyses

In Section 5.1, we present findings for objective 1 of the study and focus on whether the steps taken by the subjects matched the six stages proposed in Section 3.3 in a creative process for information seeking. Section 5.2 presents findings for objective 2 of the study and focuses on whether ACMDL and EV2 have incorporated design features to support users' creative process for information seeking.

5.1 Findings for Objective 1: Creative Information Seeking Behavior

Findings for objective 1 seemed to indicate that subjects went through similar stages in creative information seeking as those discussed in Section 3.3. The only differences among them were the query terms used and how they executed the query within the system. When these stages were compared with proposed stages in a creative process for information seeking, similar behaviors were evident. Discussion of findings following these proposed stages (see Section 3.3) are as follows:

- Preparation for starting information seeking. Subjects began information seeking by first reading and understanding the task presented.
- Chaining information sources. Subjects did not exhibit forward and backward chaining. However, subjects did some sort of chaining by picking up keywords based on the information need and specified article. They chained these keywords together to establish a query. S1 and S2 selected the title as a query term while S3

selected keywords from the title as query terms. S4-S6 used the query provided and added the article's author as a query term.

- Browsing and searching. During browsing, subjects constructed the query that mapped the system's design using previously selected query terms and executed the query. S1 and S2 did a title search using the simple and advanced search interface respectively. S3 did a keyword search in the simple interface. S4-S6 combined keyword, title, and author search to look for the article.
- Incubation for differentiating purposes. Based on information presented in the results list, subjects filtered out irrelevant records, and decided which record was most likely to be the correct one.
- Monitoring and extracting for illumination. After deciding which was the most likely record from the results list, subjects went to the actual record to extract more information about the article.
- Verification of information sources. Information extracted from the actual record was used to verify that it was indeed the correct article needed.

These findings seemed to indicate that subjects' steps taken matched the proposed stages of a creative process for information seeking except for stage #2. Findings showed that stage #2 should include aspects such as chaining of keywords to create a query other than forward and backward chaining. Certainly, more studies need to be carried out to verify these stages with different users DLs and IREs.

5.2 Findings for Objective 2: Examining ACMDL and EV2

The following paragraphs discuss findings and analyses collected for objective 2 of the study, examining ACMDL and EV2 for "features" that might support the six stages in the creative process in information seeking.

ACMDL

Stage #1 – Preparation for starting information seeking. ACMDL's features which assisted this stage were: personalized "bookshelves" for users to save relevant documents, allowing users to receive search updates based on saved queries, search guides, free access to some portions of the digital library, recommendations of relevant documents, and brief description of its domain focus. These features helped ACMDL prepare users for information seeking and ensured that it was prepared to facilitate users' information seeking process.

Stage #2 – Chaining of information sources. ACMDL supported chaining of information sources by providing links to available documents used in references of other documents, enabling links to past journals/proceedings, offering a variety of sources by ACM, and presenting index terms and subject classification of documents. These features helped users find related documents.

Stage #3 – Browsing and Searching. In terms of facilitative features for searching and browsing, ACMDL provided tools that were mapped to information seeking activities and guided users to move from novices to experts. Features implemented were: basic/advanced search interface, search fields and guides, enabling users to search similar documents, searching within results set, browse feature for different

journals/proceedings, sorting of results by relevance, title and publication date, and displaying a maximum of 200 records in results set.

Stage #4 – Incubation for differentiating purposes. Features in ACMDL that facilitated incubation for differentiating purposes involved helping users filter and establish linkages among documents. These features included: offering query suggestions when no results or spelling errors occurred; displaying a maximum of 200 records in results set; allowing results to be ranked by relevance; providing citation and abstract information in records, and automatic and personal updating of saved queries.

Stage #5 – Monitoring and extracting for illumination. Supportive features for stage #5 within ACMDL were: discussion forums for documents, sharing of documents among users, e-mail alerts of new issues of publications, and personal/automatic search updating of saved queries.

Stage #6 – Verification of information sources. Implemented features that fostered Stage #6 included: discussion forum for documents for verification purposes and feedback features for users to verify any system uncertainties with designers for further improvement.

Figure 1 highlights some features in ACMDL and the stages these features might support in the creative process for information seeking.

Figure 1. Some Features in ACMDL and Its Supportive Stages

EV2

Stage #1 – Preparation for starting information seeking. Supportive features for stage #1 included: search updates via e-mail; search guides and tips; access to librarians and subject experts; auto-stemming feature to include all variations of a query term, and different views and output formats. These features helped EV2 prepare users for information seeking and ensured that it was prepared to facilitate users' information seeking process.

Stage #2 – Chaining information sources. In terms of fostering chaining of information sources, implemented features in EV2 included: providing different types of sources from applied science and engineering domains; displaying index terms of documents, and browsing of different indexes to help users find related documents. These features helped users find related documents and understand the sub-domains in a main domain.

Stage #3 – Browsing and searching. Facilitative features for browsing and searching within EV2 were: search guides, access to librarians and subject experts, allowing browsing of index to find suitable query terms, basic/advanced search interface, search refinement, search history, reset search query, ranking of results by relevance, and viewing of records in citation, abstract and detail formats.

Stage #4 – Incubation for differentiating purposes. Features in EV2 that might foster incubation for differentiating purposes included: providing brief/detail citation and abstract information for each record; access to librarians and subject experts, and receiving e-mail search updates of saved queries.

Stage #5 – Monitoring and extracting for illumination. Facilitative features for stage #5 were: access to librarians and subject experts and allowing receipt of search updates via e-mail.

Stage #6 – Verification of information sources. Features for assisting verification of information sources in EV2 were: access to librarians and subject experts for verification and feedback features for verifying any system uncertainties with system designers for further enhancement.

Figure 2 highlights some features in EV2 and the stages these features might support in the creative process in information seeking.

6 Conclusions and On-Going Work

Through synthesizing a holistic model of creativity and an established information seeking model, six stages in a creative process for information seeking and design features were developed. These stages in creative information seeking differ from Ellis' [8, 9] information seeking model as they focus on cognitive processes in information seeking rather than behavioral activities in information seeking. Such a focus may have different implications on the design of DLs and IREs when compared with traditional information seeking models.

Findings gathered from a pilot study seemed to indicate that subjects' steps matched the six proposed stages in a creative process for information seeking except for stage #2, chaining for information sources. Findings showed that chaining for information sources should not include just forward and backward chaining but should also encompass chaining of terms to form a query. The study also inspected and found features in ACMDL and EV2 that might support creative information seeking.

This is an on-going research. Proposed stages in a creative process for information seeking and its supportive design features need to be further refined, tested, and used in real-world situations before they can emerge as stages and principles for the design of DLs and IREs to support users' creative information seeking behaviours.

More work needs to be done in objective 1 with different users, DLs, and IREs to refine the proposed stages in creative information seeking. Further work to objective 2 include studies on different DLs and IREs, and the usefulness and usability of the design features to support users' creative process in information seeking.

Figure 2. Some Features in EV2 and Its Supportive Stages

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