Appear in Proceedings of the 2007 IEEE International Conference on Advanced Learning Technologies (ICALT), 2007

A Collaborative Support Tool for Creativity Learning: Idea Storming Cube

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Abstract

Creativity plays an important role in many learning activities but how to enhance creativity with the support of modern computer tools deserves further studies. In this paper, we propose a game-based collaborative creativity support system called Idea Storming Cube to support creative thinking and help a user form a perspective-shift thinking habit. The system analyzes the knowledge acquired from the history of user inputs and compares it with the ideas possessed by the domain expert and other users in the current brainstorming group. The system is designed to provide user-, goal- and context-sensitive supports with this mechanism that stimulates more divergent thinking. We have implemented the proposed game with a magic-cube-like HCI for collaborative idea generation. A case study for preliminary evaluation of the system is also reported in this paper.

1. Introduction

In this paper, we aim to build an online collaborative brainstorming system called *Idea Storming Cube* to improve traditional brainstorming activities for creativity support. In recent years, creativity is becoming a popular issue raised in various fields such as business, industry, and academic discourse. There is no doubt that creativity is an important ability for us to improve the quality and quantity of our knowledge as well as their added values. The methodologies for enhancing creativity, such as De Bono's Lateral Thinking [5], Osborn's Brainstorming [10], had been proposed for several years. However, how to use computer or the Internet as a supporting tool to enhance creativity learning deserves further studies.

Some researchers from the field of Human-Computer Interaction (HCI) or Computer Support Collaborative Learning (CSCL) suggested to use computer- or web-based Creativity Support Tools to encourage people to generate innovative ideas. Although some work has been done on the use of Information- or Communication-type creativity support systems for idea generation [9], few studies have been conducted on the support of producing perspective-modifying ideas, which is out-of-box thinking. A notable shortcoming of most current systems is that relatively few perspective-modifying concepts can be produced due to the fact that abundant information provided by these supporting systems may not result in drastic shifts from the problem context [7]. Besides, a long-term research of Information System for creativity [4] also reveals that we should consider more external factors like people personality, learning situation, and final results. However, these issues are less concerned by present research.

Therefore, we propose to take the following three factors into account when designing a web-based supporting tool to effect the production of innovative ideas.

(1) Sharing perspectives in brainstorming activity. We try to enhance the mechanism of Group Support System (GSS) for creativity learning, especially in perspective-shift learning support. We adopt Csikszentmihalyis's theory of creativity [3] to have three stimulating type as inputs: society, domain knowledge, and individual.

(2) Providing limited view for partial problem presentation. In order to account for bounded rationality, information noise should be reduced as much as possible in incubating ideas [12]. An ideal system should be designed to properly present information as cognitive stimulation for users but also to avoid overloading users with overwhelming information.

(3) Creating an inspiring environment, possibly with the mechanism of a game. We can package the learning process into a game-based activity, such as a

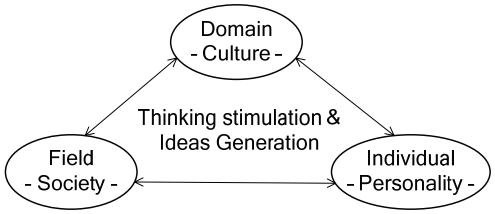

Figure 1: Csikszentmihalyi's model of creativity [3]

poker game or magic cube; in order to engage the students in learning with better motivation.

In our brainstorming application, in order to support learning by computer, we need a formal representation of ideas possessed by a user. The collection of ideas of a user is called *formal User Profiles* (*fUPs*), which records the ideas and the reasons in support of these ideas. In our system, we use a *User Profile Contrast Agent* (*UPCA*) to monitor the ideas generated by the users and then attempts to stimulate creative thinking by comparing a particular user's fUPs with others' as well as the gold-standard domain model. The UPCA can retrieve, summarize, and synthesize information presented by the current gaming peers as well as those stored in the historic *Field-Domain fUP* (*FD-fUP*) model.

We organize the rest of the paper as follows. In the next section, we will review the research pertaining to our work. In Section 3, we will present what the idea storming is and how we model the problem. In Section 4, we will use a case study to illustrate the system and conclude the paper in the last section.

2. Related studies

2.1 Creativity support tools

An ideal human-computer interaction should empower users to be more productive and innovative [11]. Designing a tool to support creativity production is becoming a popular research topic in recent years. A core issue in supporting creativity production is how to design intriguing activities that can uncover the creative mind of the user and increase the potential of a user in creative thinking.

Many researchers have proposed creativity models. Csikszentmihalyi [3] argued that the social nature of creativity should include identifying social benefits from the consultations of other domain experts, emotional supporters, and the dissemination within the field. He mentioned that individual creativity cannot leave society alone. Consequently, he proposed a system view of creativity as shown in Figure 1:

In addition, Shneiderman [11] proposed a creativity framework focusing on software implementation. In this framework, the creativity support tool is defined as a tool for peers to collect useful information, consult cross-disciplinary teams, and produce new ideas in a two-way communication. The tool also needs to be able to support the application of domain knowledge, finding related information, and providing collaborative stimulation and thinking.

2.2 Group Support Systems (GSS)

Much work in studying creativity was conducted in the field of Group Support Systems (GSS) [6]. GSS is considered as an effective technology to generate ideas of a greater quantity. Bostrom [1] suggested four important factors in considering GSS: *Person*, *Process*, *Press*, and *Product*. The measures were taken in terms of Paradigm-Relatedness, which includes *Paradigm-Preserving* (PP) and *Paradigm-Modifying* (PM). In their experiments, they found that GSS are more advantageous to support the generation of PP ideas than the PM ideas. This is regarded as a main drawback of the current GSS tools that requires improvement. Functional design of GSS is another issue to account for in designing an effective supporting system. GSS can roughly be separated into two types: *informative* and *communicative*. Ocker's study [9] compared these two types of GSS, which are the computer conferencing system and the issue-based information system. He found that the team using the computer conferencing system produced more creative solutions than the other team using the issue-based system. This result suggests that the communicative system in GSS should be able to assist users in producing more creative solutions.

However, in an unstructured knowledge creation environment, Cyert [8] regarded that in the thinking process, people only have sequential and limited attention and processing capability toward goals and subgoals. We argue that the current technologies developed for large-scale information retrieval (IR) (e.g., web searching) are still far away from an ideal supportive artifact for creativity. How the system provides user- and context-sensitive supports, and how we factor out the task characteristics are all key issues in dealing with bounded rationality [12], which are underemphasized in the current IR systems.

In sum, in designing the system proposed in this paper, we would like to consider the problems of (1) how to build a creativity support system including different perspectives from domain, field, and individuals, (2) how to stimulate users to generate more paradigm-

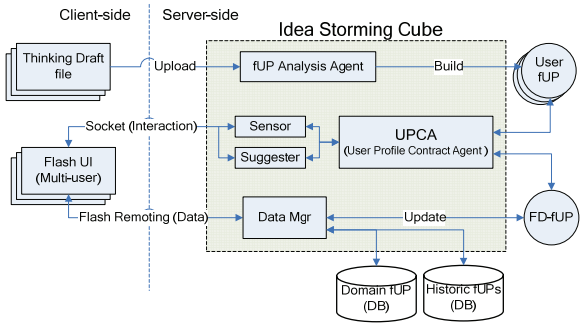

Figure 2: System architecture

modifying ideas with appropriate communicative means, (3) how to help users reduce information noise and provide assistance in an incremental manner to arouse new ideas.

3. Idea Storming Cube: an online group creativity support tool

We have developed a tool, named *Idea Storming Cube* (*ISC*), to support creativity production. In contrast to the common communicate- or information-support tools, we would like to enhance the effectiveness of such a tool by designing the following three functions in our system to achieve the above goal: 1) providing limited information view to focus on smaller partial problems 2) proceeding with a game-based brainstorming activity to inspire thinking 3) using the UPCA to find complementary ideas for each user. The overall system architecture is shown in Figure 2, and the three functions will be described in details in the following subsections.

3.1 Limited view to present problem subset

In our design we intend not to give users all information in the current brainstorming session. Instead, different users watch different subsets of the ideas that have been proposed in the current session such that each of them can relate issues in the limited context window to create new ideas preferably from different aspects. We think that knowledge or concepts for a specific problem when regarded as an abstract object can be viewed from different aspects. Different people may have different perspectives of it like different sides of a magic cube as illustrated in Figure 3(a).

The shift in perspective plays an important role in the innovative process. Therefore, we design the system to allow people to have an effective way to exchange ideas. For example, a good creative support tool for creative thinking with perspective shift could

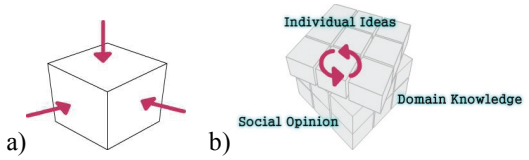

Figure 3: a) Different views of one thing b) Using fUP to model an individual, teammates, and domain experts

work like a magic cube that can be viewed and rotated in many ways as shown in Figure 3(b).

Under this circumstance, the user can only view limited information from one side of the cube. But at appropriate times, the user is allowed to rotate the cube by a row or a column to exchange ideas with others. This kind of mechanism is designed to relieve the disorder problem that a communicative information system may have [9].

3.2 Game-based activity: an inspiring environment

The ISC system works like an online poker game. Each game will require 2 to 6 participants to join. The major game steps in the process are described as follows:

1) After the game starts, the users will first be instructed to write down their initial ideas.
2) Every user will get a 3x3 array in a facet made of 9 cards. Some of the cards may have been filled with ideas (not necessarily generated by themselves), and some may be blank.
3) The system will ask the users to generate ideas as quickly as possible and fill in the cards.
4) Through the validation of the system, the user who proposes a good idea will be entitled to rotate the cube once in order to learn other good ideas that have been proposed by others.
5) In order to encourage novel ideas that may not exist in the current FD-fUP, we accredit a good idea to the first proposer if another user also proposed the same idea at a later time. This rule encourages the users to come up with more original ideas, no matter it is right or wrong, as early as possible.
6) Finally, a user wins the game if he/she can generate the largest amount of valid cards (ideas) in a pre-set time.

The system builds the knowledge model from each individual's inputs as well as the knowledge base of domain experts. By keeping track of the users' inputs, the system knows the concepts that everyone has learn-

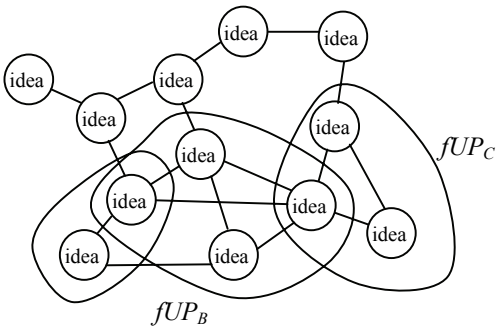

Figure 4: Comparing ideas among users

ed and thus recommends a user to acquire other people's ideas. In such a game, every player will strive to generate innovative ideas as early as possible since it is the way to get credits and to acquire new idea by other players in order to inspire even more novel ideas.

3.3 Brainstorming with the UPCA

We use a simplified model of *formal User Profile* (*fUP*) proposed in our previous work [13] to model the knowledge for idea generation. Each simplified *fUP* is a finite set: $fUP = \{I_1, I_2, ..., I_m\}$, in which I_i represents a specific concept or idea possessed by the user. Individual fUP provides us a basic sketch of each individual and is used for decision making in creativity support. Furthermore, the *Domain fUP,* denoted as fUP_d, is an fUP developed by a panel of domain experts to capture ideal solutions for the given task, and serves as a fundamental component for the system to validate the ideas of the users. The collection of individual fUPs and domain fUP will be integrated into a conceptual space called *Field-Domain fUP* (*FD_fUP*). It is built from domain expert knowledge and the society perspective described in Csikszentmihalyi's creativity model. That is, $FD\_fUP = fUP_d \cup fUP_1 \cup ... \cup fUP_n$, where $fUP_i, i = 1...n$ denote the profile of each individual. FD_fUP can be reused for the subsequent runs, and continually updated from the results of pervious brainstorming sessions.

By computing the cosine similarity between word vectors [2], a common technique in the area of information retrieval, UPCA can compare all fUP's to derive the differential sets of ideas among the brainstorming peers. For example, as shown in Figure 4, if we want to know what part of the ideas owned by User B but not known by User A, we can compare fUP_A and fUP_B with the following formula:

$$fUP_{I_b} = (FD\_fUP - fUP_A) \cap fUP_B$$

Figure 5: Dialog bubbles for feedback and arrows for rotation suggestion are displayed when a novel idea is recognized by UPCA

array

1 IDEAS_COLLECTION

query - Top 2 of 2 Rows

	CELLID	IDEA	IDEAID	NAME	NOMINATOR	SCORE	VALID	VALIDBY
1	2	開塑嚴重	97	Jacky	2	4	1	p1-idea04
2	5	水土保持不好	110	Jacky	2	4	1	p1-idea07

2 IDEAS_COLLECTION

query - Top 1 of 1 Rows

	CELLID	IDEA	IDEAID	NAME	NOMINATOR	SCORE	VALID	VALIDBY
1	15	水土保持不佳	99	Cindy	1	4	1	p1-idea07

3 IDEAS_COLLECTION

query - Top 1 of 1 Rows

	CELLID	IDEA	IDEAID	NAME	NOMINATOR	SCORE	VALID	VALIDBY
1	25	剛下過豪雨	103	Alice	19	4	1	p1-idea02

Figure 6: The ideas generated by the users as recorded by ISC

By exposing User A to some of the thoughts from User B, we hope that appropriate cognitive stimulations [8] can be created for User A. By keeping track of the user's profile, the system can also avoid presenting redundant information to the user.

4. Use case

Here we demonstrate a scenario with three users (Jacky, Cindy and Alice) learning the concepts of the *Debris Flow Hazard* problem by brainstorming activities in the ISC system. Each user is arranged to face one side of the cube and asked to input as many ideas (causes of debris flow) as possible. When a novel idea is recognized by UPCA in FD_fUP, the system will give the user appropriate feedback and credits as shown in Figure 5.

The system records the ideas that each user has inputted as shown in Figure 6. The UPCA compares the ideas with fUP_d, but also with other users in order to

find out the ideas that can be used to inspire a specific user. For example, in the example of Figure 6, the fUP's of all the users are the following:

fUP_{Jacky} = {idea04, idea07}
fUP_{Cindy} = {idea07}
fUP_{Alice} = {idea02}

UPCA uses the following formula to find the new ideas for Cindy:

$$fUP_{I_b} = (FD\_fUP - fUP_{Cindy}) \cap fUP_{Jacky} \cap fUP_{Alice}$$

The resulting idea set is {idea04, idea02} with one idea from Jacky and another from Alice. The system can then locate the cards containing these ideas in the cube, and then display blinking arrows to propose rotation suggestions to Cindy for getting these ideas.

Finally Cindy will be allowed to rotate a row or a column of the cube at her will to exchange ideas with others. The winner would be the one who can contribute as many novel ideas as possible when the game is over. In other words, a user can gain credits by contributing novel ideas that have not been proposed before. As a reward, the user is allowed to rotate in a row or column to get a better understanding of information in the cube. Consequently, each player will strive to be productive in idea generation in term of speed and quality in order to win the competition.

The ISC system continuously computes the fUP of each user to make it as a support to others. However, the system does not rotate the cube voluntarily for the users. Instead, in the competition, the system only prompts the user with the possible rotations that he/she can make to attain new ideas. It is also a probable strategy for the user to keep an unrecognized idea in his/her side as a secret and hope that it can be accredited when another user contributes the same idea. The final decision on what to rotate still relies on the users.

Through the competition, we hope that the user can strive to come up with high-quality novel ideas quickly. By limiting the view of a user to a few ideas, the system allows a user to concentrate on generating related ideas based on the current view. In other words, the system makes use of the concept of rational boundary to increase the quality of generated ideas, and it also uses the cube mechanism to gradually change the view to inspire new ideas.

5. Conclusion

In this research, we have designed a new group support system called Idea Storming Cube to support creativity learning and perspective-modifying thinking. Based on the theory of rational boundary, we design the ISC system to expose limited view of the whole domain to the user in order to infer related ideas. The system runs as a game to increase motivation and encourage efficient and effective production of novel ideas. In addition, users can explore new ideas with the helps of the User Profile Contrast Agent (UPCA). A prototype system has been implemented and ready for testing. Further experiments and analysis will be conducted soon in order to evaluate the effectiveness of such a system and verify our hypothesis.

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