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A Multifunctional System for Supporting Collaborating Works and Decision Making

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Abstract: The objective of this study is to present a brainstorming-based multifunctional system which supports collaborating works on creativity activity and decision making. Brainstorming has been recognized as an effective group decision supporting approach. Go with the technology shift, brainstorming has been evolved from traditional, electronic, to currently web-based version. There are advantages and disadvantages in each of version. The development of Information and Communication Technology (ICT) takes giant leap in last decade. In this study, a new version of brainstorming platform is proposed and constructed with multimedia and various ICT technologies. The objective of this proposed system is to keep and enhance the advantages of brainstorming approach and makes the disadvantages as few as possible. A comparison between several versions was made. This comparison shown that the proposed system is superior to others from system functions point's of view. A user satisfaction survey based on TAM model was conducted at a college in Taiwan. The result shown that these senior students felt this system was useful and easy to use for group creative tasks.

Key words: Brainstorming, group creativity, scratching, instant messenger, ICT, TAM

INTRODUCTION

Information and communication technology opens tremendous possibilities for virtually every segment of society. It provides fast, convenient and powerful computing and communicating approaches which facilitate information gathering, sharing, analyzing and archiving. Creativity is one of key factors which affect national competitiveness. With regard to creativity activity, traditional approaches have been enhanced with ICT. Brainstorming is one of the most famous and easiest creativity promoting methodologies. For many years, it has been proved that brainstorming is an effective approach to generate ideas whether in group creativity or individual practice (Fan, 2008; Mendikoa *et al.*, 2008; Kunifuji and Kato, 2007). Traditionally, brainstorming has had some disadvantages which may be eliminated with ICT.

The research found that the quantity and quality of ideas generated by groups which adopt group decision support system software are better than their traditional counterparts (Gallupe *et al.*, 1992; Lin and Yuan, 2006). Elan and Mead (1990) found that the number of ideas is significantly increased in a brainstorming session supported by group decision support system. Klein and Dologite (2000) found that the ideas generated by a group using group decision support systems are more creative. The construction of a creative environment includes the

establishment of physical supporting tools and the system of motivating participants to actively communicate with each other (Isaksen *et al.*, 2000). Stenmark concluded that electronic brainstorming systems are a suitable supporting tool for creative activity, but it lacks in group identity. When a reward system which emphasizes competition and individualism is established, group identity becomes a key factor. In this manner, a suitable identity method should be built into an electronic brainstorming session. Zhang *et al.* (2005) applied frame-based information structure in electronic brainstorming (EBS) and argumentation to support group decision task generation and identification. Potter and Balthazard (2004) claimed that Electronic brainstorming applications and their methodologies may have achieved the benchmark of enabling interactive users to perform as well as nominal groups. The current challenge is to view this as a plateau and not an endpoint and to seek ways of improving EBS performance.

With regard to creativity, Dewett (2003) pointed out that information technology provides following three special obvious advantages: enhance the capability of connecting team members, improve the capability of knowledge base inside organization and enhance boundary spanning capabilities. Dewett (2003) claimed that information will affect domain related skill significantly. It will also have important influence upon

task motivation through the development of individual autonomy. Edmondson and Moingeon (1998) claimed that individual is easier to get important and related information by way of information and network technology, it will increase the possibility of creative problem solving. There are divergent and convergent thinking activity in creative problem development process, Desautels and Monge (1999) found that the efficiency of divergent thinking activity of electronic style is better than of face to face style.

To improve the performance of electronic brainstorming system, in this study, a multifunctional web-based brainstorming system is introduced. This system incorporates many contemporary ICT technologies to eliminate the drawbacks and enhance the process of traditional brainstorming activity.

BRAINSTORMING OVERVIEW

Brainstorming is an approach used to stimulate creative thinking that was first introduced by Alex Osborn (1963). Brain storming is a kind of skill in which a person or a team applies mental power to practice creative thinking and generates numerous ideas for a specific problem in a short period of time (Litchfield, 2008; Brown, 2008; Osborn, 1963). According to the observations of Dennis and Williams (2003), traditional brainstorming has the following potential advantages:

- **Synergy:** It means a participant's idea triggers another participant to create a new idea. This new idea may not be created under other circumstances
- **Social facilitation:** A person's effectiveness is influenced by the presence of other people

Brainstorming also has the following potential disadvantages:

- **Production block:** Only one person is allowed to speak at a time in traditional brainstorming. Therefore, participants speak in a round robin fashion, which may block a participants' output, since they must wait for their turn to speak.
- **Evaluation apprehension:** A participant may be afraid of expressing an idea due to worry about his/her idea receiving negative feedback from others.
- **Social loafing:** Some individuals may tend to create fewer ideas in group brainstorming than in independent brainstorming.
- **Cognitive interference:** Someone's opinion or comment may interfere with another participant's thinking during group brainstorming.

Kay found that electronic brainstorming has the following advantages over traditional brainstorming (Kay, 1995):

- **Parallel entry of ideas:** All participants may express their ideas simultaneously, which does not affect other's thinking or block other participants from expressing their ideas. With respect to each participant, the chance to express an idea is equally available and the production block is decreased dramatically
- **Anonymity:** Session participants are anonymous in brainstorming sessions. Therefore, they need not worry about criticism from other participants. Anonymity may also stimulate the feeling of participation in the discussion
- **Novelty:** Electronic brainstorming is a novel group discussion technology for many people. It may stimulate a participant's interest and curiosity
- **Size:** In contrast to the optimal group size of 5 to 12 persons in traditional brainstorming, the group size has no limitation in electronic brainstorming
- **Proximity:** No matter where session participants are located, all participants can attend sessions. They only need a computer, the proper software and networking capability
- **Memory:** Even though not all participants may attend a session on time, participant(s) who missed the session may understand the session process and get all session records with an automatic session message recording mechanism of an electronic brainstorming system
- **Software/tools:** Ideas created during a session should be evaluated and electronic brainstorming sorts and evaluates ideas with the help of software tools
- **Equality:** Session participants are not affected by the necessity to wait to give input or by the presence of other participants. No one can affect another's thinking or limit another's participation

Although there are many advantages to electronic brainstorming, there are some disadvantages as well. Dennis and Williams (2003) pointed out that communication speed is an obvious disadvantage. People used to express their ideas or thoughts through oral communication, while with electronic brainstorming, people use a keyboard to type their ideas or thoughts. Someone who is unfamiliar with the layout of a keyboard, would type slowly, therefore communication would be slower. Recently, many researchers have devoted themselves to web-based brainstorming research. Hwang *et al.* (1998) proposed a web-based brainstorming

approach in which data acquisition, generation and editing of ideas and evaluation of ideas are three essential steps. This system has a complete methodology and process which acquires data, improves original ideas, edits ideas and evaluates ideas. Unfortunately, it still keeps the above mentioned disadvantages of electronic brainstorming as open issues. Yuan and Chen (2008) devised an automated decision agent called the Semantic Ideation Learning Agent (SILA) that can represent a session participant who is actively participating in brainstorming. Their preliminary evaluation results showed that the proposed system advances E-brainstorming by crossing the three key boundaries of human ideation capability (understanding, cognition boundary and endurance). Hwang (2004) developed a web-based brainstorming system for idea and alternative generation about engineering projects (Hwang, 2004). The existing commercialized brainstorming systems have better functions but still lack in some areas, such as on-line evaluation made by domain experts, information sharing and drawing functions, etc.,

SYSTEM DESIGN

Decision supporting systems help people to make a decision in which complex procedures and processes are involved. There are many methodologies for facilitating the process of decision making; some of them even have software tools to support the group decision process. Brainstorming is an easy and convenient approach to allow groups or individuals to make decisions. In this study, a multifunctional system is proposed to enhance traditional brainstorming. This system is a web-based system which is integrated with the strength of web. The objective of this system is to strengthen brainstorming activity with contemporary information technologies. The main functions of this system are a web-based scratching pad called FlashPaint, a search engine is included to make searches inside this system or outside Internet and perform knowledge management and an expert evaluation interface. The functional stack of this system is shown in Fig. 1. The major functions of this system are as follows:

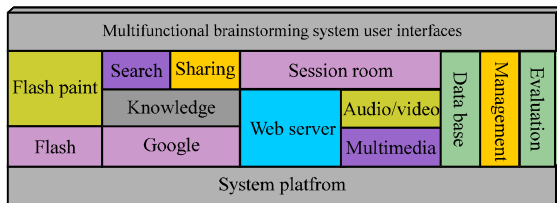


Fig. 1: System functional stack

- A picture is worth a thousand words is a famous saying, it is especially true when sharing or discussing some newly born ideas. There is no clear definition on how drafting is incorporated into brainstorming session. There is an activity called Brainsketching which has same functions and advantages as brainstorming, but can compensate the disadvantages of brainstorming. The procedure of brainsketching is as follows: every participant draws his idea on a paper independently. Then, every participant passes his/her ideas to a nearby participant after 15 to 20 min. Any participant who receives another’s idea can draw something which follows the previous idea, or make a brand new idea (Zurita *et al.*, 2008; Edmondson and Moingeon, 1998; Desantics and Monge, 1999). With the help of multimedia function, a convenient scratching pad (called FlashPaint), is incorporated into this framework (Remko van der Lugt, 2002). This scratching pad, which is similar to Microsoft’s MSpaint software, lets participants make free hand scratchings, with a mouse or other pointing device. After that, the scratching can be saved into the database in text data format (Fig. 2, 3). Once it has been saved, other participant can view this scratching in a dynamic animation style, as if the participant who made this scratching were making this scratching again. This is a very good approach to share ideas with others using the exact sequence as the original scratching was made. In addition, new drawings can be appended into an existing scratching. For example, a participant uses this tool to demonstrate a solving process of an equation and other participant may find some missing points on this solution process. The other participant then appends some further processes into this existing solution. After that, this scratching is a combination of these two participants and the animation process will show both of the solution processes

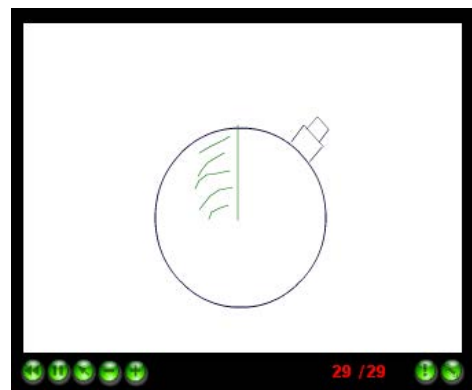


Fig. 2: A snap shot of flash paint

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~184112|~180117|~177122|!200118189120|~183121|~17812
5|~175131|!202130197Y1|!~192132|~186136|~182141|~1781
46|!199143193145|~187148|~185153

Fig. 3: Data set of Fig. 2

- In this system, participants can search within this system or the outside world with the Search function. For a certain period of time, if many brainstorming sessions have been conducted in this system, then abundant conclusions or ideas should be in the system database. These materials may be served as a valuable reference material for participants of a brainstorming session. Or, a session participant may search the web to find some additional reference material. With the help of this function, participants can find as many reference materials as they need. That is impossible to achieve in traditional brainstorming. This function is a kind of knowledge management tool, since it manages knowledge in an organized form and will present it to someone who needs it at any time
- When a session participant finds some valuable material on the web and is willing to share with other participants, the Information sharing function can be used. Participants can save the web page they want to share into a file, make the necessary annotations and upload it into the system database; then other participants can view this shared web page. The reason for saving whole web page instead of URL is that participants who make this sharing can point out what they want to share to others and misunderstandings are minimized
- To avoid embarrassment and hesitation, giving comments or criticism is strictly prohibited during traditional brainstorming session; it may not be the same situation in web-based situation. Owing to the anonymity, any participant except session master does not know which idea is posted by whom. Yu (2005) stated that positive comment may encourage people to stimulate and share more creative idea. Michinov and Primois's research showed that both group productivity and group creativity are better in the social comparison feedback condition than in the other condition. It appears that social comparison process has a positive impact on productivity and creativity in a web-based context of asynchronous electronic

brainstorming. This finding provides some useful recommendations for learning facilitators to improve productivity and creativity in the context of computer-supported collaborative learning over the Internet (Michinov and Primois, 2005). There is a Comment function in this system in which participant can select a suitable comment from a set of predefined positive comments to a creative idea. The reason for selecting a predefined comment instead of writing a comment is to avoid negative and offensive comments

- The messages made in a session are arranged in chronological order. Sometimes, a participant may want to review what he/she or someone has made in this session. At this time, a searching/sorting function can be used
- Domain experts may be invited to evaluate the quality of generated ideas upon completion of a brainstorming session with the evaluation function. There is a convenient function to invite domain experts; therefore experts can make evaluations on-line. In such an environment, experts around the world can be invited. After the evaluation period, the session master and participants can view the evaluation results
- In general, a brainstorming session takes 30-60 minutes. If participants anticipate the need to start another round of brainstorming to continue a previous incomplete session, they may ask a session master or system administrator through system functions. If the session master grants this request, another round is started
- Brainstorming is a kind of group decision support systems, participants contribute their ideas and thinking in a session. The conclusions are made by all participants and the reward is given to all participants. Someone may hesitate to contribute their ideas since once they contribute, the ideas are no longer theirs but belong to all. The situation gets worse in a company that provides a good incentive to an employee who gives a creative idea. In traditional brainstorming, a session master knows who gives which idea; therefore session master can make judgment on who contributes most during the session. To keep the anonymity, every participant uses a unique number given by the system instead of a real name or identification in a session; all participants do not know who posts a certain idea except the idea owner in an electronic or web-based brainstorming system. In this system, session master knows the real identities of each participant; therefore, a participant is not afraid of stolen ideas

- If one of the session members is stuck without saying a word for a while (e.g., 10 min), then session master may ask and assist he/she privately without interfering with the session progress and causing embarrassment
- In web-based or electronic brainstorming, text is the most common approach to giving ideas. In general, oral communication is more natural than text input. In this system, a participant may use an offline mp3 recorder such as Super mp3, provided by Admiresoft (2008), to record what he/she wants to share in an oral way. Video clips can also be used if necessary. After recording an audio/video clip, a participant can upload this file into system; then other participants can view it. Multimedia, such as audio and video, is an effective and convenient approach for group communication. However, if multimedia is adopted, care should be taken if it affects the anonymous advantage that electronic brainstorming has over its traditional counterpart

To demonstrate the process and usage of this system, a simple usage scenario and a flowchart (Fig. 4) is given. Generally, the activity on this system is divided into three stages: the preparation stage, in session sages and finishing or continuing stages.

Preparation stage:

- The system administrator creates a user account and session room on request. Then, an e-mail is sent out

- The session master and session participants will receive an invitation e-mail to invite them take part in a brainstorming session

In session stage:

- At the schedule time, session master and participants log into this system with the appropriate log into this system with the appropriate user name and password given by the system administrator. Session master takes charge of this session with the master functions, while session participants generate and share their ideas with functions provided for participants. At this stage if guest function is activated, a guest may enter session room and view the discussion result, but he/she can not take part in the session activity

Finishing stage:

- Upon the completion of a session, system administrator or session master will arrange the generated ideas and invite domain experts to evaluate these ideas
- Domain experts evaluate these ideas with expert functions
- Session master and participants may view the evaluation result. They may ask for a follow-up session if they feel it needs another round for the same topic. It will initiate another session but a connection with the previous one will be given

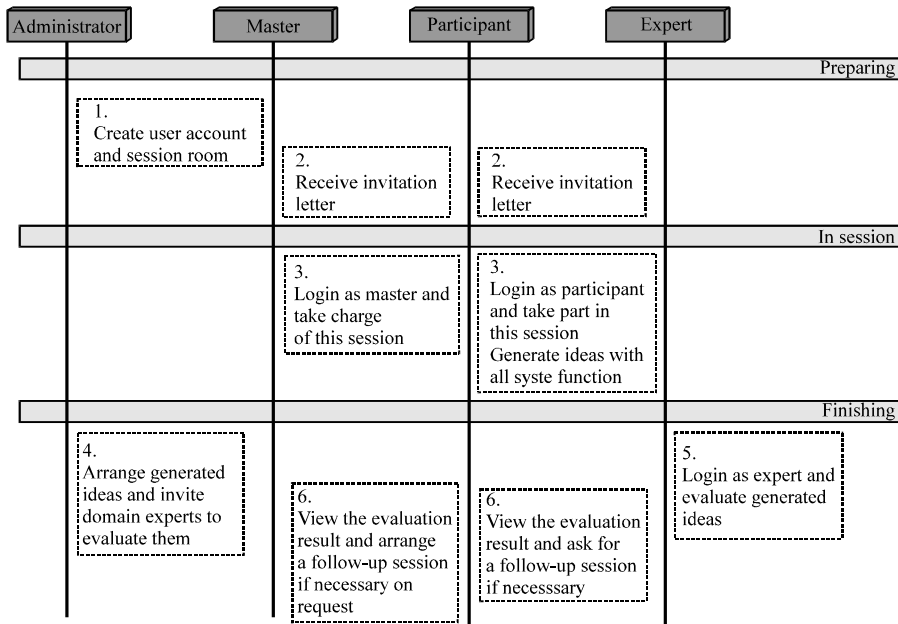


Fig. 4: Flow chart of system usage

SYSTEM EVALUATION

To evaluate the effectiveness of this system, two approaches are used: a comparison between several possible methods and a user survey about system usefulness. The comparison is from technical point of view.

A comparison: With regard to functions provided in this system, a comparison is made between several possible approaches: traditional, electronic, instant messenger and the system proposed in this study. A traditional approach is a face to face approach and similar to Osborn's definition. An electronic approach uses tel-conferencing, chat room, or discussion board. An instant messenger is a most common communication channel on the web; the most famous are Microsoft MSN, Yahoo Messenger and SkyPe.

To make comparison, some features should be identified. By viewing the conclusions made on the past researches, the authors claim that a web-based brainstorming system should have following features:

- **Anonymous:** This is one of the most obvious advantages, it should be retained
- **Scratching pad:** Picture is an easy and convenient communication means. It will improve the performance
- **Search:** Web is a treasure of knowledge; a web-based system must have such feature
- **Information share:** Sharing additional information to other participants makes communication easier
- **Positive comment:** Giving positive comment to other participants will encourage them to share ideas

- **Reward given:** Letting participant don't be afraid of idea stolen
- **Expert invitation:** Inviting experts who are at different location to evaluate ideas
- **Evaluate ideas on line:** Letting experts to evaluate on line
- **Initiates another follow-up session:** Letting participants to request another follow-up session
- **Multimedia:** Providing an alternative way to text input

By looking into Table 1, it is obvious that the system architecture presented in this paper is superior to other counterparts with respect to brainstorming.

User satisfaction survey: This system was a tool for group creativity on a creative design course opened in the fall semester of 2005 at a college in Taiwan. There were 47 students, who were seniors with majors in automation engineering took part in this course. At the end of the course, a user satisfaction survey was conducted to investigate how these students felt about this system. This survey was a modified Technology Acceptance Model (TAM) (Bagozzi *et al.*, 1992; Davis, 1989). Except scratching function, more than 80% of students felt all other functions were useful and easy to use for creative thinking. Around 64% of students felt the scratching function was useful for expressing ideas (Table 2). The possible reason is that some students may think it takes time to make a meaningful picture. Generally speaking, most of the students felt this system is useful and easy to use.

Recently, Instant Messengers (IM) such as MSN and Yahoo Messenger has become popular communication approaches. Many of people who have experience on the

Table 1: Comparison of four different approaches

Topic	Traditional	Electronic	Instant messenger (MSN or Yahoo Messenger)	Present system
Anonymous	No	Yes	Yes	Yes
Scratching pad	Yes (blackboard)	No	Yes	Yes
Search	No	No	Yes	Yes
Information share	Difficult	No	Yes	Yes
Positive comment	Not Allow	No	No	Yes
Reward given	Yes	No	No	Yes
Expert invitation	Difficult	No	No	Yes
Evaluate ideas on line	Difficult	No	No	Yes
Initiates another follow-up session	Yes	No	No	Yes
Multimedia	Yes	Yes	Yes	Yes

Table 2: User satisfaction survey based upon a modified Technology Acceptance Model

Question	5* (%)	4* (%)	3* (%)	2* (%)	1* (%)
The full text search function is useful for me on information searching	30.0	57.5	12.5	0.0	0.0
The full text search function is easy to use for me on information searching	26.2	61.9	11.9	0.0	0.0
I think the information sharing function is useful	16.7	71.4	11.9	0.0	0.0
I think the information sharing function is easy to use	11.9	69.0	16.7	2.4	0.0
I think the scratching function is useful for expressing idea	16.7	47.6	33.3	2.4	0.0
I think this system promotes my creative thinking	21.4	76.2	2.4	0.0	0.0
I think this system is easy to use	16.7	69.0	14.3	0.0	0.0

*5: Strongly agree, 4: Agree, 3: No comment, 2: Disagree, 1: Strongly disagree

Table 3: Advantages of IM and the proposed system

Instant messengers	System presented in this study
Easy to use	Easy to make a drawing
Many functions	Anonymous expressing ideas
File sharing	Ideas and expressions of all sessions are kept in database
Better screen display	Powerful search function
A lot of symbols	Easy to organize own and other's comments and ideas
User interface is more comfortable	Dynamic animation of scratching
Easy to invite friends	
Invite someone to share a application	

web also have experience on MSN or Yahoo Messenger. To understanding what student felt about IM and our system, students were requested to make a comparison between IM and this system. About 53% of students felt this system function is superior to MSN in creative thinking (Table 3). This is a quit surprising result. The possible reason is students are quite familiar with IM and only used such a dedicated brainstorming system at this course. Therefore they thought these two systems were equally suited for group creative thinking. It gives us a new direction to think about in the role of popular communication approaches.

CONCLUSION

With the assistance of information technology during the creative thinking activities, participants had ennumerable opportunities to practice their creative thinking skills. This system indeed improved their creative thinking ability. In addition, participants have further understood the fundamentals of creative thinking through actual participation in related activities. Present system is an effective tool for creative thinking that gives positive help to individual as needed. As an example, the drawing pad gives positive help regardless of an individual's thinking process or his/her understanding of other's thinking. We believe that the use of this tool will play a key role in the creative thinking process in this information era. By providing a suitable tool, the process of creative thinking and an individual's thinking ability can be continually enhanced. The influence upon the promotion of creativity and decision making with domain related tools is seldom an issue on the past creativity researches. The tools, especially computer-based tools, give major contribution on embodying the conceptual matters. For example, there are system simulation, computer aided design and computer aided manufacturing at mechanical domain, there are computer animation and computer drafting at art domain. Csikszentmihalyi called the creation, which affects and even changes the human civilization, the Big C (Csikszentmihalyi, 1996). Csikszentmihalyi (1966) pointed out that there are three important subsystems at creative process: individual, field and domain. Csikszentmihalyi and Wolfe (2000) applied

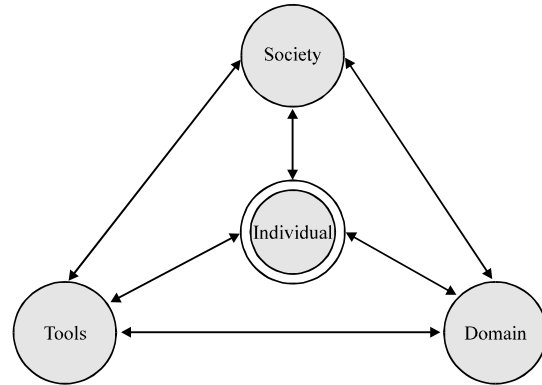


Fig. 5: The modified model of creativity activity

this conclusion on school education. They thought that school is consisted of three parts: domain which deliveries knowledge to students; teacher who controls the knowledge, this is the system related field; and student whose task is to learn knowledge, then generate the content which makes contribution to society and field. Based on this observation, the model proposed by Csikszentmihalyi and Wolfeis (2000) was modified to add a tool component as shown in Fig. 5. In this proposed model, in addition to individual, domain and society, the tool component is added. In the future, more experiments and observations will be conducted to further verify our conclusion about the effectiveness of the tool component in creative activities.

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