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A Collaborative Support Tool for Divergent Thinking: Idea Storming Cube

Chun-Chieh HUANG, Chun-Yen CHANG, Tsai-Yen LI, Hao-Chuan WANG

Abstract

Divergent thinking ability plays an important role in many learning activities. In this paper, we propose a game-based collaborative creativity support system called Idea Storming Cube to support divergent 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 tool with a magic-cube-like game for collaborative idea generation. A preliminary evaluation of the system is also reported in this paper.

1. Introduction

In this paper, we aim to explore an online collaborative brainstorming system called *Idea Storming Cube* to improve traditional learning activities. In recent years, creativity or divergent thinking is becoming a popular issue raised in various fields. There is no doubt that it is an important ability for us to improve the quality and quantity of our knowledge. The methodologies for enhancing this ability, such as De Bono's Lateral Thinking, Osborn's Brainstorming, 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 [5], 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 [4].

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 and we try to enhance the mechanism of Group Support System (GSS) for creativity learning, especially in perspective-shift learning support. (2) Providing limited view for partial problem presentation in order to account for bounded rationality and information noise (3) Creating an inspiring environment, possibly with the mechanism of a game, in order to engage the students in learning with better motivation.

2. Related studies

For the happening of creativity, Csikszentmihalyi [2] 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.

As for supporting creativity, Shneiderman [6] 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. Furthermore, much work in studying creativity was conducted in the field of Group Support Systems (GSS) [3]. GSS is considered as an effective technology to generate ideas of a greater quantity. For the evaluation of GSS, Bostrom suggested the new measures that were taken in terms of Paradigm-Relatedness, which includes *Paradigm-Preserving* (PP) and *Paradigm-Modifying* (PM) to judge the divergent thinking. 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.

However, in an unstructured knowledge creation environment, Simon [7] regarded that in the thinking process, people only have sequential and limited attention and processing capability toward goals and sub-goals. 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 [7], which are underemphasized in the current IR systems.

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

We have developed a tool, named *Idea Storming Cube* (*ISC*), to support creativity production. 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) supporting by providing complementary ideas for each user.

The shift in perspective plays an important role in the innovative process. Creative thinking with perspective shift could work like a Magic Cube game that can be viewed and rotated in many ways as shown in Figure 1. 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 of the information system.

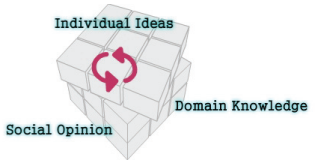

Figure 1: Exchanging ideas among different perspectives

The ISC system works like a Magic Cube game. After the game starts, the system will give the users a problem-solving task and the users will get a 3x3 array in a facet made of 9 blank cards like one face of a Magic Cube. The system will ask the users to generate ideas as quickly as possible and fill texts in the cards. The answer validation of the system is below:

R1: A user can get a full credit and a chance to rotate the cube when he/she proposes a new idea which no one has written before and is validated by the system. The suggestion for rotation provides the user with other users' valid ideas that he/she has not seen before.

R2: A user can get a partial credit when he/she see others' ideas that he/she has not seen before.

R3: A user does not get any credit if he/she proposes an idea that has been proposed before.

R4: A user does not get any credit if he/she has proposed an invalid idea. However, he may get a credit in the future if another user proposes the same idea after him/her.

We use a User Modeling technique proposed in our previous work **錯誤! 找不到參照來源。** to model the knowledge for idea generation. By keeping track of the users' inputs, the system knows the concepts that everyone has learned and thus recommends a user to acquire other people's ideas. In such a game, every player will strive to generate different 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 ideas related to the task.

4. Preliminary experiment

We have conducted the study on evaluating the system to compare the effects of system support. This experiment was conducted in June 2007, in a computer classroom at Taipei Municipal Nanhu High School. There were a total of 54 11th-grade students involved in this experiment. All of them have taken an introductory course on earth science. The duration of the experiment was approximately 45 minutes including the pre-test, different group treatments, and the post-test.

We adopted a different brainstorming type of comparison-group approach to investigate the comparative effects that students worked collaboratively on an idea generation problem within an Information-based, Game-based, or Game&Agent-based condition, and their function comparison as shown in Table 1.

Table-1: The comparison of three groups

	Info-based ISC	Game-based ISC	Game&Agent-based ISC
Information-sharing window	√		
Game competition rules		√	√
Agent support			√

We want to compare the effect of the game stimulation between the ISC_{info} group and the ISC_{game} group, and the intelligent support effect of the peer-like agent between the ISC_{game} group and the $ISC_{game\text{-}agent}$ group.

For the game stimulation, we concern about the students' aspiration and whether they have the right thinking direction when they play this brainstorming game. To measure this, we record the number of each student's submitted ideas. In addition, we consider that peer-like agents should be helpful because students may encounter *Idea blocking*. Hence, we need measurements for the outcome and use group as the evaluation unit. We would like to know the coverage of different idea category and the number of unique ideas that each group proposed. Therefore, this experiment used the following variables as predictors to predict the students' Paradigm-Modifying outcome and the comparison with the measurements the Torrance Test of Creative Thinking (TTCT) [42] are showed as below:

Table 2: The comparison of the measurements between ISC and TTCT

Idea Stroming Cube	Torrance Tests of Creative Thinking **[8]**
The number of submitted ideas	Fluency (total number of meaningful ideas)
The number of unique valid ideas	Originality (statistical rarity of the responses)
The number of unique valid ideas of each category	Flexibility (the number of different categories)

* The measurement 'elaboration' did not be used here

An analysis of variance (ANOVA) was computed on the pre-test data and found that all of them are not significant ($p > .05$) among three groups. In order to examine and compare the effect of these three groups, an ANOVA was conducted on those measurements as mentioned above.

Table 3 shows the results of Scheffe test of submitted ideas of individual and unique valid ideas of group. For the number of submitted ideas of individual, there was a significant difference between two pairs of groups which were ISC_{info}-ISC_{game} and ISC_{info}-$ISC_{game\text{-}agent}$, but no significant difference between ISC_{game} and $ISC_{game\text{-}agent}$. This result indicates that the game competition within brainstorming seems better for participants to generate ideas than information-sharing type of brainstorming. For the number of unique valid ideas, it shows that the ISC_{game} group is more helpful for generating different unique ideas than the ISC_{info} group and the $ISC_{game\text{-}agent}$ group is even better than the ISC_{game} group.

Table 3: The results of Scheffe test for the number of submitted ideas and the number of unique valid ideas of group.

Scheffe	Submitted ideas - Mean (SD)		
	ISC_{info}	ISC_{game}	*p*
	20.17 (8.85)	33.58 (11.80)	0.011
	ISC_{info}	$ISC_{game\text{-}agent}$	*p*
	20.17 (8.85)	34.00 (14.15)	0.013

Scheffe	Unique ideas of Group - Mean (SD)		
	ISC_{info}	ISC_{game}	*p*
	10.25 (1.89)	12.12 (0.64)	0.024
	ISC_{game}	$ISC_{game\text{-}agent}$	*p*
	12.12 (0.64)	14.16 (0.40)	0.006
	ISC_{info}	$ISC_{game\text{-}agent}$	*p*
	10.25 (1.89)	14.16 (0.40)	0.000

Table 4 shows the results of Scheffe test for the unique valid ideas of each category, and it indicates that there were significant differences in both categories between the ISC_{info} condition and the $ISC_{game\text{-}agent}$ condition. This result explains that the ISC_{game} group is more helpful in generating different ideas than the ISC_{info} group and the $ISC_{game\text{-}agent}$ group is even better than the ISC_{game} group.

Table 4: The result of Scheffe test for the count of unique ideas in Human Development and Policy

Scheffe	Human Development - Mean (SD)			Policy - Mean (SD)		
	ISC_{info}	ISC_{game}	*p*	ISC_{info}	$ISC_{game\text{-}agent}$	*p*
	4.00 (1.41)	5.88 (0.99)	0.023	0.25 (0.50)	1.83 (0.75)	0.004
	ISC_{info}	$ISC_{game\text{-}agent}$	*p*	ISC_{game}	$ISC_{game\text{-}agent}$	*p*
	4.00 (1.41)	6.50 (0.54)	0.005	0.50 (0.53)	1.83 (0.75)	0.004

5. Analysis and Discussion

We observed many using behaviors in different types of brainstorming-support systems and evaluated what kind of system support could help students have more diverse thinking. We assumed that an interesting game-based environment is more useful than Information-based brainstorming-support system. The major reason is that the game competition may enhance students' concentration on their brainstorming task. Relating it back to the result of this experiment, we

can find that the number of submitted ideas and the number of valid ideas were significantly different between the different types of brainstorming system with/without game rules.

Regarding the divergent thinking ability, we would like to know the effect of the peer-like agent support with game competition rules. The experimental results show that the game-based brainstorming-support system with a peer-like agent has better performance comparing with the game-based-only brainstorming-support system. We may infer that good performance on divergent thinking can be observed by giving some effective support when the users encounter idea blocking. However, many studies show that the productivity loss is even greater in groups than in individuals. It is suggested that the individual version of this system should be considered in further studies.

Summarizing the result obtained in this experiment, we can see the effect from the game competition rules and the peer-like agent support by comparing three different types of conditions. It is suggested that the game-based brainstorming system with appropriate intelligent support is applicable because this brainstorming-support system can make them think more from diverse view points for learning the knowledge.

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. The system runs as a game to increase motivation and encourage efficient and effective production of novel ideas. 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. In addition, users can explore new ideas with the helps of the User Profile Contrast Agent (UPCA). The system has been implemented and more pedagogical experiments and analysis will be reported soon.

6. References

[1] R. P. Bostrom, "Research in Creativity and GSS," *Proc. of the Thirty-First Hawaii Intl. Conf. on Systems Sciences*, IEEE, Kohala Coast, HI, pp.391-405, 1998.

[2] M. Csikszentmihalyi, "Society, culture, person: A systems view of creativity," *The nature of creativity*, Cambridge University Press, pp. 325-339, 1988.

[3] N. Duncan and D. Paradice, "Creativity in GDSS: An integration of creativity, group dynamics, and problem solving theory," *Proc. of the Twenty-Fifth Hawaii Intl. Conf on Systems Sciences*, Kauai, Hawaii, 1992.

[4] M. Nagasundaram and B R. P.ostrom, "Structuring Creativity with GSS: An Experiment," *Proc. of the First Americas Conf. on Information Systems*, Pittsburgh, PA, pp. 25-27, 1995.

[5] R. Ocker, S. R. Hiltz, M. Turoff, and J. Fjermestad, "Computer support for distributed asynchronous software design teams: Experimental results on creativity and quality," *Proc. of the Twenty-Eighth Hawaii Intl. Conf. on Systems Sciences*, Hawaii, pp. 4-13, 1995.

[6] B. Shneiderman, G. Fischer, M. Czerwinski, M. Resnick, B. Myers, L. Candy, E. Edmonds, M. Eisenberg, E. Giaccardi; T. Hewett; P. Jennings; B. Kules; K. Nakakoji, J. Nunamaker; R. Pausch; T. Selker; E. Sylvan, M. Terry, "Creativity Support Tools: Report From a U.S. National Science Foundation Sponsored Workshop," *Intl. J. of Human-Computer Interaction*, 20(2):61-77, 2006.

[7] H.A. Simon, *Models of Man*, Wiley, New York, 1957.
[8] Torrance, E. P., Torrance Tests of Creative Thinking, Lexington, MA: Personnel Press, 1974.
[9] H.-C. Wang, T-Y. Li, C-Y. Chang, "A user modeling framework for exploring creative problem-solving ability," *Proc. of 12th Intl. Conf. on Artificial Intelligence in Education (AIED 2005)*, pp. 941-943, 2005.