World Scientific
www.worldscientific.com

EVOLVING A SOCIAL VISUALIZATION DESIGN AIMED AT INCREASING PARTICIPATION IN A CLASS-BASED ONLINE COMMUNITY[*]

JULITA VASSILEVA[†]

Computer Science Department, University of Saskatchewan, 110 Science Drive,
Saskatoon, SK S7N 5C9, Canada[‡]
jiv@cs.usask.ca

LINGLING SUN

TELUS Business Transformation, Suite 1103, 10020-103 Ave. NW
Edmonton, A T5J 0G8, Canada
gloriasun@yahoo.com

The paper describes the evolution of the design of a motivational social visualization. The visualization shows the contributions of users to an online community to encourage social comparison and more participation. The newest design overcomes shortcomings in the previous two, by using more attractive appearance of the graphic elements in the visualization, better clustering algorithm and by giving up the largely unused in the previous design user customization options. The visualization integrates more information in one view, and uses an improved user clustering approach for representing graphically their different levels of contribution. A case study of the new design with a group of 32 students taking a class on Ethics and Computer Science is presented. The results show that the visualization had a significant effect on participation with respect to two activities (logging into the community and rating resources).

Keywords: participation, online communities, social visualization, social comparison.

1. Introduction

Lack of participation is one of the most common problems encountered by those who try to use an online community for a given purpose, e.g. to share knowledge or experience in an organization, to initiate discussion related to a class, or to provide a shared repository for resources. Even when the software infrastructure supporting the community is well designed, functional, and usable, the users do not naturally flock to it. In those cases where online communities have been successfully deployed, usually some special measures or incentives have been introduced to motivate and sustain user participation. Such incentives are, for example, incorporating the requirement for a certain level of participation in the performance evaluation criteria, providing a salary bonus, or a grade

---

[*] This is an extended version of a paper that appeared in Proceedings CRIWG'2007, Bariloche, Argentina.
[†] To whom all correspondence should be addressed.

component for a class grade based on participation in the community. However, in certain cases even without external incentives, or in addition to them, users participate, seemingly motivated by social factors, like prestige. For example, some communities maintain "top user" lists showing the users listed by their participation or contribution (measured according to some metric, e.g. number of questions answered, number of resources shared etc.). It seems that such a "hall of fame" can play a positive role in encouraging participation in some communities. We have explored this idea by using a social visualization emphasizing user participation in the context of a online community supporting university students to share class-related resources (web-links).

 This paper describes the evolution of our visualization design focusing on the latest version. The paper organized as follows. In the next section, the related work including some theoretical underpinnings of the approach is discussed. Section 3 briefly describes the two previous designs and the results of their evaluation. Section 4 presents the latest design, section 5 – the evaluation of this design in a case study and section 6 discusses the results obtained. Conclusions and directions for future research are given in section 7.

2. Related work

Motivation for participation has been studied in various disciplines: psychology, behavioral economics, and social psychology. Various theoretical frameworks for motivation exist in psychology. According to the Cognitive Evaluation Theory, there are two motivational systems: *Intrinsic* and *Extrinsic*. Extrinsic motivators are pay, promotion, feedback or working conditions. Intrinsic motivators are achievement, responsibility and competence. Maslow's hierarchy of needs[1], and several subsequent theories, like Alderfer's ERG theory[2] and McClellan's theory of acquired needs[3] emphasize that humans have inherent need for: belonging and esteem (Maslow), relatedness and growth (ERG theory), and for affiliation, power and achievement (acquired needs theory). To ensure motivation for participation, an online community should be designed so that it supports the fulfillment of these intrinsic needs.

There are theories of motivation that emphasize extrinsic motivation. For example, according to the equity theory[4] people compare the ratio of reward to effort with the comparable ratio of reward to effort that they think others are getting and decide if it is worth to spend the effort or not. According to the reinforcement theory[5] based on Skinner's operant conditioning motivation for particular actions can be achieved by positive and negative reinforcement, extinction and punishment.

Behavioral economists have studied altruism, reciprocation and social norms of human cooperation. In numerous experiments[6] it has been shown that humans tend to reciprocate, or return favors, and initiate cooperative acts expecting reciprocation by others in the future.

Social psychology has studied motivation mostly in the context of persuasion, which has important implications for marketing and public policy/opinion formation. Several theories are relevant here. The Cognitive consistency / dissonance theory[7] states that

people try to keep consistent their behavior and attitudes to other people and things (e.g. causes). If there is an inconsistency, it causes discomfort and people will react in different ways – for example, by denial, by rationalization and excuses, by separation of items, transcendence, or persuasion - changing their attitudes to create a consistent balanced view. One implication is that after people have made a commitment they are more likely to act in a consistent way with their commitment, since they feel uncomfortable otherwise[8]. Cialdini[9] identified six factors that explain people's tendencies to comply with a request:

- reciprocation (people tend to return a favor, thus the pervasiveness of free samples in marketing),
- commitment and consistency (people tend to honor their commitments, even if the original incentive is removed after they have agreed),
- social proof (people will do things that they see other people are doing),
- liking (people have difficulty saying "no" to people they like, which explains viral marketing),
- authority (people tend to obey authority figures, e.g. the infamous Milgram experiments with subjects playing prison guards and prisoners),
- scarcity (perceived scarcity generates demand, e.g. "limited time offer" is more likely to generate sales).

 Festinger[10] created the social comparison theory showing that people tend to compare their achievements and actions with people who they think are similar to them in some way. For example, when a student wants to know if she is good at math, typically, she compares herself with the other students taking the same math class, rather than with her professor. When there is no suitable peer group, people will compare themselves with almost anyone. On the other side, when one knows that others will compare with him/her, one acts more responsibly. People normally want to be positively recognized in their community and are willing to make an effort to gain social reputation, providing the effort is affordable and worthwhile compared with the potential benefit of the reputation. Competition[11] is a form of upward social comparison in which one compares and tries to "fit in" with the elite, top-performing sub-group. Competition has been viewed as affecting motivation negatively, especially by educational psychologists, due to the presumed negative feelings of people comparing themselves with people who perform better than them. However, recently there has been emphasis on the self-enhancing effect of social comparison[12], especially upwards comparison (competition), emphasizing the positive feelings of people who compare favourably with others, and the motivationational effect of considering better performing individuals as role models.

  All of these theories have been developed for real communities. Yet, there is increasing evidence[13] that they have validity in online communities too. It seems that social comparison and competition can motivate participation in users in online communities too. Sheperdd et al.[14] showed that social comparison decreases social loafing and increases productivity in groups that are brainstorming and sharing ideas in e-collaboration. By inducing social comparison with graphical feedback tool and increasing the salience of that social comparison with facilitation techniques, the authors increased

the productivity of electronic brainstorming groups by 63 percent. This shows that the designers of software infrastructures for online communities can exploit social comparison to influence user behaviour.

One approach to increasing participation in online communities is to encourage social comparisons by using visualizations. By making the presence and activities of other users visible – not only those that are vital for the community, e.g. discussion posts in a discussion forum, shared files in a Peer-to-peer filesharing system, but also peripheral (non-essential) activities and their effects – a *socially translucent space* is created. A socially translucent space, as introduced by Erickson and Kellog[15], supports awareness of the presence and activities of other users and thus encourages social comparison. A socially translucent space creates conditions for social norms of behavior to become activated, for example, Cialdini's factors can start to effect user behavior. Being aware of other users can activate reciprocation. Commitment and consistency are encouraged through the user's awareness that others are aware of her actions and will expect reciprocation and keeping to her commitment. Social proof is established and relationships or liking or disliking can be built. Finally authority can be established, e.g. by seeing that a certain user has a special status and scarcity – by seeing that there is only a small elite group of high-status users in the community.

There has been work in the HCI community, for example, Ref. 16, 17, 18 dealing with participation and visualization. Generally, the focus of HCI research has shifted from pure usability issues to sociability issues in the last 10 years. Yet the main focus of most of these works is on dealing with information overload, rather than participation.

Erickson[19] proposed a number of guidelines for designing social visualizations for online communities. He makes an important distinction between "translucence" and "transparency", emphasizing that the information shown in the visualization does not necessarily have to be very detailed and exact. In most of the cases, it is better just to give the user a general idea, and even in some cases a certain level of misrepresentation may be beneficial. Also, customization should be avoided; all users should see the same thing so that they feel responsible for their actions, since they know that others see the same things as they and are aware of what they do.

General visualization design guidelines have been developed in the visualization community. They use certain physiological properties of human vision and are aimed at reducing cognitive overload and increasing usability. The choice of visual metaphor is very important: an appropriate metaphor is intuitive to use and does not require a complex legend for interpretation. Applying a hierarchical structure [20, 21] and using composable layout and visual sets[22] are helpful when designing information-compact visualizations of large networks. A proper use of location and color contraction of visual components will successfully attract attention[23]. "Richly expressive information visualization is difficult to design and rarely found" (from Ref. 24), so it is always beneficial to make the visualization easily reusable in similar situations.

Our social visualization was designed keeping these principles in mind with the purpose to create social translucence that is conductive to social comparison and

competition. Our main hypothesis was that this visualization will encourage more participation in the community with respect to the activities presented in the visualization. The next section describes the first two designs of the visualization and the online community in which it was implemented.

3.   First Two Designs of the Social Visualization

The Comtella community (http://umtella.usask.ca/um) allows students to share, search, and rate online resources (both links/urls and files). Thus it is functionally similar to social bookmarking systems such as Technorati and CiteULike, but it pre-dated them by several years. Comtella evolved through three versions since its initial design in 2002. While designing the Comtella system we had a very practical goal to create a system that is useful for sharing resources in our lab and in class and the system has been deployed (in different versions: P2P, centralized P2P and web-based) in real setting with 20-30 users at a time since 2003. In the same time we also had the goal of using the system as a research tool to explore different ways of motivating user participation and contributions. An overview of the first two designs of the visualization in Comtella is presented in Table 1. The visualization was designed to present in an intuitive and attractive way the relevant information about user participation[25] . Scalability, simplicity/intuitiveness and aesthetics were our guiding principles in choosing a representation metaphor and in the graphics design. An ugly, boring, and hard to understand visualization is less likely to be used and will less likely have motivational effect. For this reason, unlike most existing social visualizations (e.g. those of social networks), we did not try to pack as much information as possible using standard visualization tools, such as graphs, charts, or trees. In our first visualization design we used a starry sky as a metaphor (see Fig. 1a) where each user who was online at the moment of viewing was represented with a star with visual parameters (size, color) reflecting certain participation aspects of the user[25]. In the second design shown in Fig. 1b we had to retract to a more simplistic graphical representation, but we kept the same metaphor. The change was necessitated by the evaluation results of the first design. In contrast to using a general summative measure of overall participation as we did in the first design, in the second design we set some more refined participation targets - to encourage social comparison in several different activities, and for each topic of the class. The user feedback from the evaluation of the first design called for interactivity. Thus in the second version of the visualization [27]. the view of the community was generated on click by the user after selecting a criterion. Interactivity was deemed important also by the instructor, since she wanted to encourage social comparison and competition with respect to several participation dimensions: bringing new articles, downloading (and presumably reading) articles from others, logging in the system frequently. She feared that once students have achieved the highest level of participation (largest size) they would stop participating. We hypothesized that enabling different views would allow students to find which dimension of participation they were lacking in and they will improve their participation accordingly. The requirement for interactivity necessitated using circles instead of stars, because they were

simpler to generate on request, but this simplicity lead to a less attractive visualization overall. To lessen the impression of loneliness that users felt in the first design, the second design of the visualization displayed all users, not just those that were online at the moment.

Table 1: The Purposes, Community Models and Visualizations in Comtella.

| **Design 1:** Comtella is a P2P-based system for sharing academic papers (details in Ref. 25)	**Design 2:** Comtella is a centralized P2P system supporting students in a class to share class-related online resources (details in Ref. 26)
Goals	
Encourage sharing **original** papers, encourage **re-sharing** downloaded papers from others, **encourage giving rather than taking** from others (reciprocity). Encourage users to compare themselves with users sharing papers **in the same area** of interest. Important to see those users **who are online** currently. **Not important to see the evolution** of contributions. Not important to see the quality of contributions.	Encourage high number of contributions for each topic (week) Encourage bringing **new** papers for the current topic (the current week in class) **Reciprocity** isn't very important (due to the centralized repository) Encourage users to compete in **topics of their choice** and for **different kinds of participation** (new contributions, ratings, comments, login frequency). Important **to see everyone** (both online and offline) **Important to see the evolution** of contributions High-quality contributions and Ratings Not specially encouraged
Visualization Design	
Users – shown as *stars* Individual contribution – *size* of star (analog) **Reciprocity – shown with different *color*** (blue star – user that mostly takes from others, red star – user from whom others take) Visualization shows **only the stars of users** *currently online*. *Groups (galaxies) of stars* show communities interested in a given topic (topics persist in time). *The Position* of a star in a group is random **No way to see the past contributions** *Clicking* a star shows on the left side of the window all shared files (and their topics). No distinction between the quality of contributions of different users.	Individual users – shown as *circles* Individual contribution level – *size* of star (discrete - 4 levels) **Reciprocity is not shown**. *Colour* is not used *State* of a circle: *filled* – represents user who is on line, *empty* **circle – represents offline user** Visualization provides different "*Views*" selected by the user by *weekly topic and* by *participation type (original contributions, total contributions, comments, status/membership)* *Default view* – "original contributions" for current topic (week) *The Position* of circles on the screen is fixed - sorted in order of decreasing contribution **Views showing contributions for *previous topics*** (weeks) Visualization *does not* represent the quality of contributions / participation
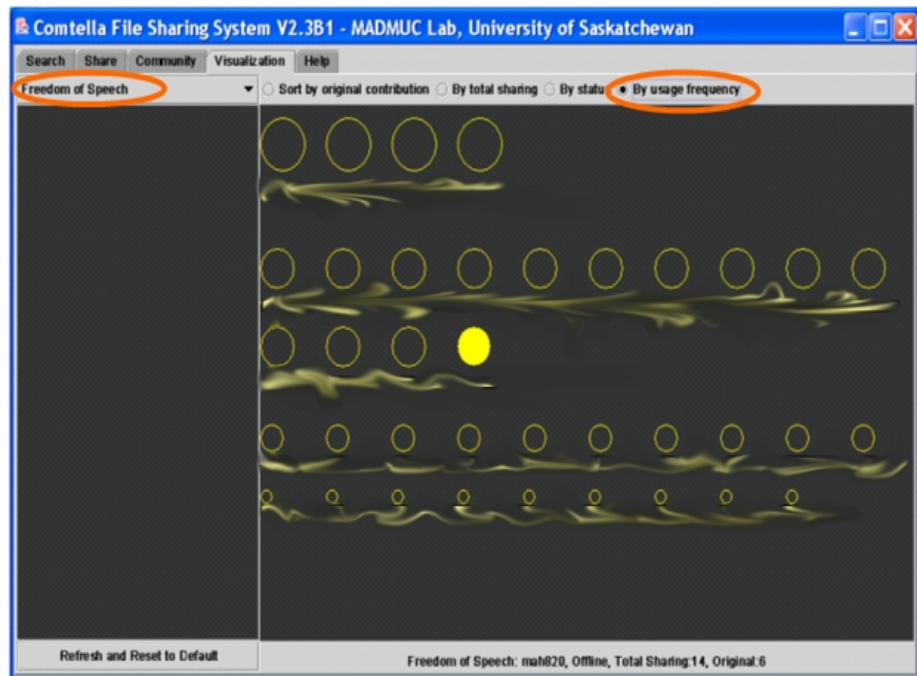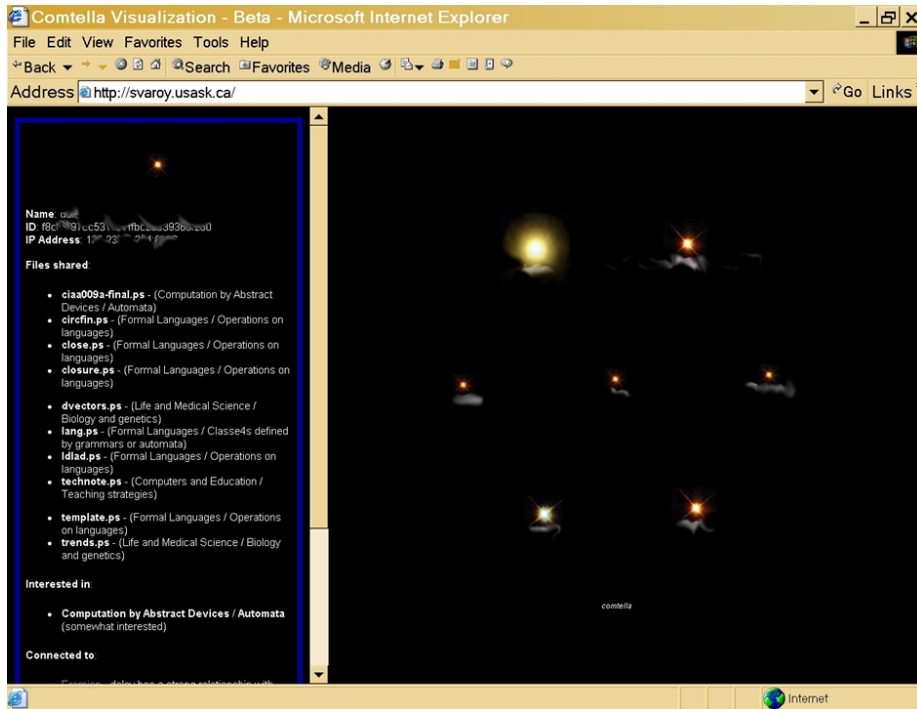
Fig. 1. The first and second design of the visualization (usernames unreadable for privacy)

The evaluation of the second design [26, 28] showed that the visualization did in fact increase participation (we observed close to doubling the number of contributed papers after the visualization was introduced). Some of the users engaged in very actively in the

competition and, unfortunately, some attempted (successfully) to game the system and contribute a many papers of low quality to increase their stars. Therefore, a new design goal emerged – to encourage the contribution of high-quality papers. It became necessary to measure the reputation of users as a function of the ratings their papers obtained from other users. The visualization had to represent the user reputation in some appropriate way to encourage social comparison in this dimension.

Another observation was that the second, interactive design did not help in encouraging social comparison along different activities, because the students did not use the interactive features of the visualization. Instead, they accessed almost exclusively the default view. The default view represented just one dimension of participation (number of original papers contributed) and this dimension accounted for all the increased participation in the system; the other dimensions of participation did not show significant increase (apart from the number of total contributions, which is derivative of the number of original contributions and is in this version of the system meaningless, since duplication of resources is unnecessary, due to the centralization of the P2P system). Therefore, interactive views were not incorporated in the third design.

The user feedback from the evaluation of the first design called for less ambiguous graphical language (the users weren't able to distinguish between the smooth differences in the sizes of stars and the different colors). Thus in the new design, the circles representing the users were shown sorted according to the particular dimension of participation and clustered in four different sizes, to simplify the distinction (due to the difficulty that the analog sizes caused in the first design). However the clustering algorithm that we used was very rigid, based on thresholds. It could happen that two users differing only by one unit of contribution are represented with circles of different size, which was considered unfair by some users. Obviously, the classification algorithm had to be improved.

The attractiveness of the visualization in the second design was rated as low. Therefore we had to find a way to show more realistic / attractive stars. The next two sections present in more details the third design and its evaluation.

4. Third Design: Encouraging Participation in a Web-based System

The new design of the visualization had a new, more complex visual language, more attractive stars, a new clustering algorithm. The visualization uses again the nigh-sky metaphor. However, we use a more complex visual language. Unlike the previous design which used just two dimensions: the size (four possible sizes) and color (yellow filled circle or black empty one), in the current design we use four dimensions: size, colour, level of brightness and shade.

Each star also has a particular color and a certain level of brightness of that color. The color of a star indicates the membership level of the represented user (Fig.2a). The membership (status) is a combined measure of the user's participation which depends on the number and quality of the user's contributions (new links and ratings). A yellow star

represents a user who holds Gold membership, a white star represents a user who has a Silver membership, a red star, a Bronze membership, and a Green star, the lowest "plastic" level of the membership (the initial membership level for everyone when s/he first starts to use the system).

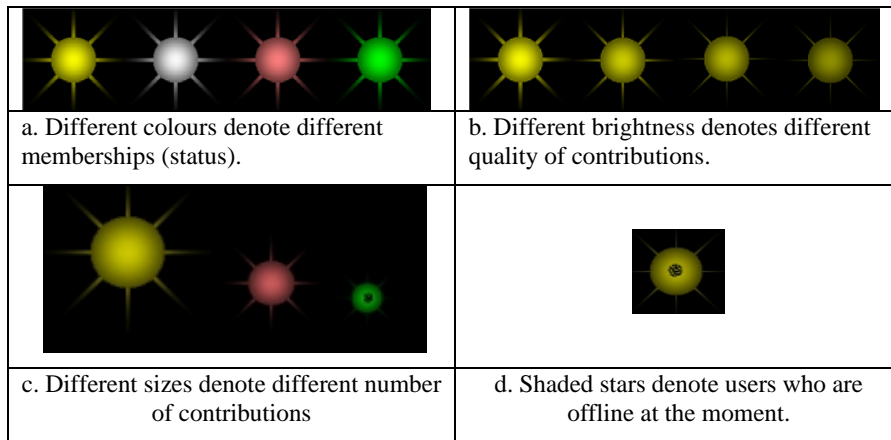|	
a. Different colours denote different memberships (status).	b. Different brightness denotes different quality of contributions.
c. Different sizes denote different number of contributions	d. Shaded stars denote users who are offline at the moment.

Fig. 2. The four dimensions of the graphical language

Each star has a certain level of color density, which visually appears as brightness, to represent the reputation level of a user (Fig. 2b). There are four levels of reputation. Brighter stars represent users with higher levels of reputation.

The size of a star indicates the number of links shared by the represented user (Fig.2c). There are four possible levels of contribution: the users who contribute the most links are at Level 1, and the users who contribute no links – at Level 4.

If the center of a star is covered a by a black shade, this indicates that the represented user is currently offline, otherwise, s/he is online (Fig. 2d). In this design, "a user is offline" means that the user has not been active in the past ten minutes in the Comtella community. A user may have a combination of any contribution level, membership level, reputation level, and be either online or offline.

The arrangement of the stars in representing the users in the visualization is fixed (see Fig. 2), while in the previous design it was a result of dynamic sorting according to the criterion chosen by the user. In this way the user can easily locate him/her self as s/he gets familiar with using the system. Each user can create his/her alias, under which s/he is known in the community. The users can see their alias name and the aliases of their peers by moving the mouse on top of a star.

Our hypothesis was that this design will continue to motivate users when they have already become good contributors, which was one of the problems in the previous design. It is almost impossible for a user to achieve the highest levels in all criteria, e.g. having the first contribution level, gold membership, and highest reputation. In this way, there

will always be a way of improvement for the user, or a factor that motivates a user to contribute.

As Fig. 3 shows the largest star does not necessarily have to be a gold member or the brightest star. This is because the size of a star is solely determined by the number of contributions (shared URLs) by the represented user, while the membership is calculated based on other criteria (the quality of these contributions, as well as by the number and quality of ratings given by the user for the contributions of other users). Some users may feel satisfaction from becoming the brightest small green star, by contributing only a few but highly rated papers.
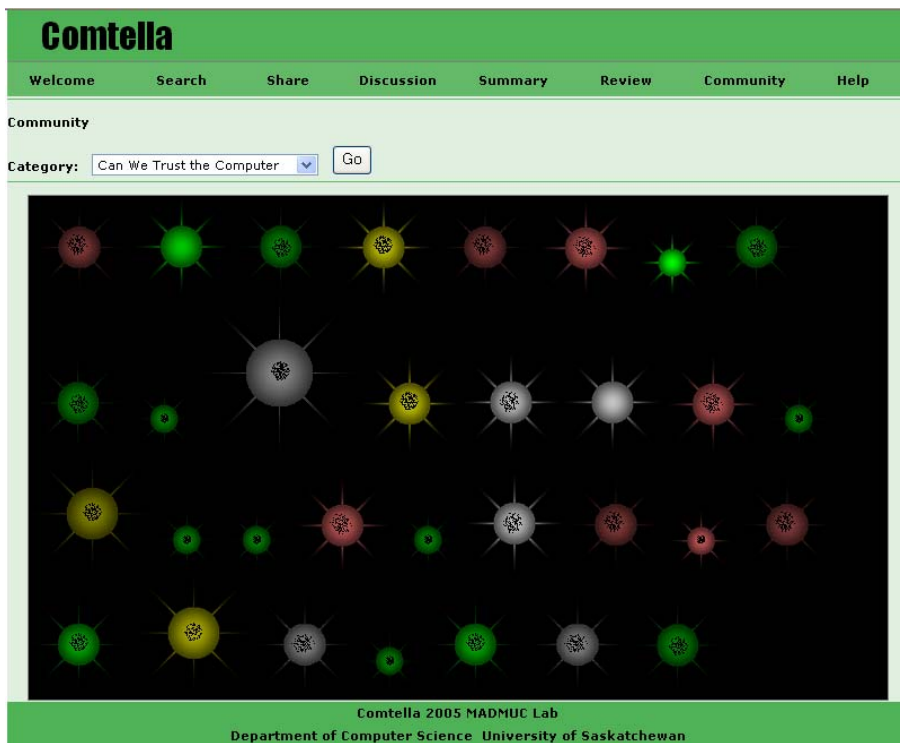

Fig. 3. A screen shot showing the new design of the visualization.

The images used to represent users in this visualization design are cartoon versions of stars on a black background. In this design we gave up the idea of generating the stars on user request for the goal to having more realistic/beautiful stars. However, unlike the first design of the Comtella visualization, we did not use JPEG images of real stars since they could not be manipulated consistently in terms of colors and brightness to achieve the variety of sizes, colours and different levels of brightness that we wanted to have in the new version. The pictures we used in this design are pre-generated by a program written in OpenGL, and saved as .PNG files after being processed by Microsoft photo editor.

The size of a star was determined based on the number of new contributions by the user in a given week using a new classification algorithm. This algorithm was designed to solve the problem of insignificant boundaries between two consecutive clusters of users when classifying these users into different contribution levels. This problem was obvious in the previous design and created feelings of unfairness in the students who were close to the margins of different contribution classes. With the old algorithm, the first contribution level should always contain the top three users, and according to the contributions for topic 1 (i.e. the first column in Fig. 4), for example, some of the zero-contributors will be classified into the first contribution level, while the rest will be classified into the other levels, which is obviously not fair.

topic 1	topic 2	topic 3	topic 4	topic 5	topic 6	topic 7	topic 8	topic 9	topic 10	overall
3	5	14	14	24	28	23	15	20	20	124
0	5	8	10	19	28	15	15	13	10	111
0	4	7	10	16	21	11	10	11	8	102
0	2	6	9	12	15	10	10	8	6	77
0	1	5	9	10	12	8	10	7	6	69
0	1	5	7	8	11	7	6	7	6	58
0	1	5	7	6	11	6	6	6	6	49
0	1	5	7	6	11	6	6	6	6	48
0	0	5	6	6	11	6	6	6	5	47
0	0	5	6	6	9	5	5	5	5	45
0	0	5	6	6	9	5	5	5	5	43
0	0	4	6	5	7	5	5	5	4	40
0	0	4	5	5	6	5	5	5	4	39
0	0	4	5	5	6	5	4	4	3	38
0	0	4	4	5	6	4	4	4	3	35
0	0	4	4	4	5	4	4	4	3	34
0	0	4	4	4	5	4	3	4	3	34
0	0	3	4	4	5	4	3	4	2	33
0	0	3	4	4	4	3	3	3	2	32
0	0	3	4	3	4	3	3	3	2	29
0	0	3	3	3	4	2	2	2	0	28
0	0	3	3	3	3	2	2	2	0	25
0	0	2	2	3	3	1	0	2	0	18
0	0	1	2	3	3	0	0	0	0	15
0	0	1	2	2	2	0	0	0	0	13
0	0	0	1	2	2	0	0	0	0	11
0	0	0	0	0	0	0	0	0	0	4
0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	0	0	0	0

Fig. 4. An example output of the classification algorithm. The users whose number of contributions are shown in cells colored in yellow are classified in contribution level 1, white – contribution level 2, orange – contribution level 3, green – contribution level 4.

The new algorithm prevents this unfairness. It is illustrated in Fig. 4, and works as follows:

(i)   Sort in a list (L) the users in descending order of their contributions for a given topic.

(ii)   Set everyone who shares nothing with a contribution level = 4.

(iii)   If everyone shares something, but they all share the number of files i.e. make the same contribution, set their contribution level = 3.

(iv)   Else:

- Find the biggest gap in contributions among the top 20% of the users in L and mark it gap_1. For example, if the biggest gap in this range falls between user A and user B, where A is in front of B in L (i.e. A shares more than B), then gap_1 = the index of A in L. Set users before gap_1 with a contribution level = 1.

- Find gap_2 which is the biggest gap after gap_1 among the top 50% of the users in L, and set contribution level = 2 to all the users after gap_1 but before gap_2.

- Find gap_3, the biggest gap among the rest of the users, and set everyone between gap_2 and gap_3 with a contribution level = 3, and those after gap_3 with a contribution level = 4. However, if there are some users who have not contributed anything, then gap_3 will be the index in L of the last non-zero contributor.

The brightness level is computed using the average reputation of the user's shared URLs (referred to as "paper-reputation" in the following context) defined in Ref. 27. If the highest paper-reputation of all the users, either online or offline, is H then everyone whose paper-reputation is H will have the brightest star (i.e. the highest reputation level). If a user's paper-reputation is less than H, for example r, then another value R is computed as $R = r/H$. If $R > 0.9$ with an allowable margin of 0.05 (i.e. $R > 0.85$) then this user will also have the brightest star; otherwise, if $R > 0.55$ then this user will have a second brightest star (i.e. reputation level 2); otherwise, if $R > 0.35$ then this user will have a dark star (i.e. reputation level 3); and if $R <= 0.35$ then this user will have the darkest star (i.e. lowest reputation level), which makes it almost fade into the background.

5. Case Study of the Third Design

This design of the visualization was evaluated in a case study with a group of 32 forth-year computer science students taking CMPT 408, a class on Ethics in Computer Science, offered by the Department of Computer Science from January 17 to April 8, 2005, a total of 12 weeks. The first 10 weeks were dedicated to the experiment and the last two weeks were for the online questionnaire survey. The list of categories for sharing URLs corresponds to the topics discussed in the class. Each topic was discussed in one week following the class curriculum, except for "Computer Crime and Security" in the middle of the term which was discussed for two weeks with the reading-week break in between, so this topic ran over weeks 4, 5, and 6. Submitting URLs of papers related to the topic of each week was part of the coursework, rewarded with marks (5% of the course grade). In order to minimize the effect of the external reward on the students motivation to contribute to the community, all students received the same marks if they submitted a minimum of 3 links per week, i.e. bringing in more links was not rewarded.
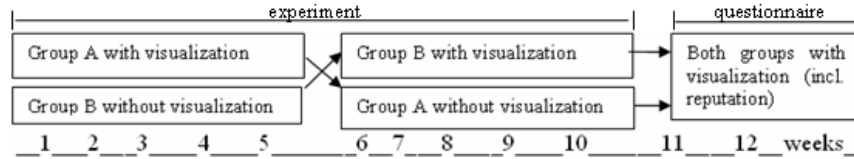
Fig. 5. Experiment Time Schedule

The experimental subjects were divided randomly into two groups of equal size, 16 students in each group, and the experiment duration was split into two equal parts as well, 5 weeks in each part (see Fig. 5). The midnight on Sunday February 20, 2005 was the "switching point" — at this point the two groups were switched so that Group A, who had access to the visualization during the first five weeks, was not able to use the visualization any more, and Group B, who was not able to use the visualization in the first five weeks, gained access to the visualization. The reason for switching the two groups in this way was to reduce as much as possible the ordering effects and the effect of novelty. However, the novelty effect could not be entirely eliminated. In the case of this experiment, it was stronger on Group A than it was on Group B because Group A was the first group who had access to the visualization, so for them both the system and the visualization were new. The subjects in Group A had no knowledge about the visualization when they were exposed to it, but the subjects in Group B had at least heard about the visualization from their colleagues, with whom they shared classes, and worked on the class project. So the visualization was not as new to Group B as it was to Group A.

The hypothesis was that the visualization would motivate the subjects to contribute more papers and ratings and to participate more actively in the Comtella online community by logging in more frequently and reading more papers.

The quantitative results about the participation of the two groups are shown in Fig. 5. The dark dashed line in each chart represents the performance of the Group A and the lighter solid line represents the performance of Group B with respect to each activity. The X-axis shows the time duration of the experiment in terms of weeks, starting at Week 1 and ending at Week 10. The Y-axis shows the number of times subjects logged in to the Comtella system. Each data point represents the total number of activities of a given type for all students in the corresponding group and week. The groups were switched at midnight on the last day of Week 5 i.e. the beginning of Week 6. Weeks 4, 5 and 6 were dedicated to the same topic and the students, shared most of their URLs on this topic in Week 4 and almost nothing in weeks 5 and 6. Moreover, Week 5 was the reading-week break. This explains the big drop in Week 5 in each of the figures 6a-d.

Figure 6a represents the total number of logins made by the subjects each group on a weekly basis and Figure 6b represents the number of ratings given by subjects in each group on a weekly basis. Giving ratings is a major type of activity in the Comtella community. It takes effort to read and evaluate the material, and the rating constitutes a valuable contribution to the community since reasonable ratings will guide users to find good articles. Another important type of contribution is sharing papers (URLs). Figure 6c compares the number of URLs shared by the subjects of Group A with the number of

URLs shared by the subjects of Group B on a weekly basis. Figure 6d represents how many times subjects from each group read a paper shared by others in the community (as a read we count just opening the URL of the paper).

a. The Number of Logins of students from Group A vs. Group B

b. The Number of Ratings Given by Group A vs. Group B

c. The Number of Papers (Shared URLs) contributed by Group A vs. Group B

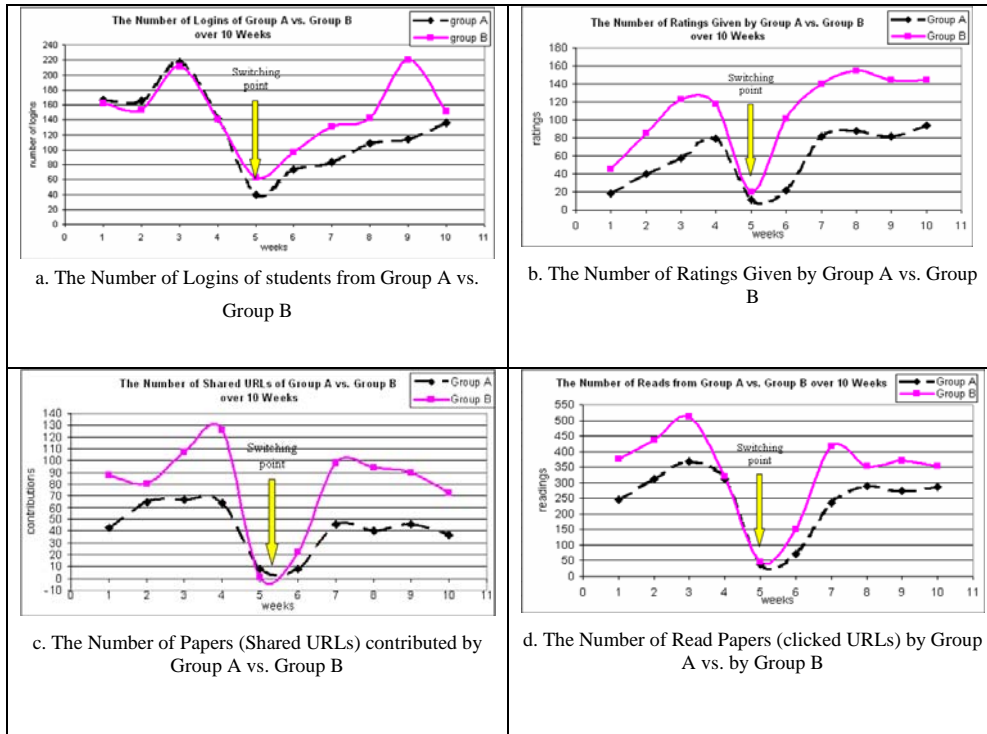d. The Number of Read Papers (clicked URLs) by Group A vs. by Group B

Fig. 6. The different types of participation by the students in Group A compared to those of Group B.

It is clear from Fig. 6 that there is a difference between the participation of Group A and Group B. Group B participated more actively than Group A in all activities. Since the experimental subjects were assigned randomly into groups, it happened so that one group contained more active members than the other. In this case, we need to adapt our hypothesis to correspond to this unintended bias. The modified hypothesis, that takes into account the fact that one of the groups (B) is more active is based on the original hypothesis: that the visualization would motivate both groups to participate more. This means that it is expected that the difference between the participation levels of the two groups would be smaller when the less active group has access to the visualization and the more active group does not have access to the visualization (which is the case during the first period of the experiment, before the switch). On the contrary, the difference between the participation levels of the two groups would be larger when the more active group has access to the visualization and the less active group does not have access to the visualization (the case during the second period of the experiment). Figure 7 illustrates

the effect of the growing difference between the participation level (we will call it "performance" for brevity) of the two groups in the two periods of the experiment according to the modified hypothesis.
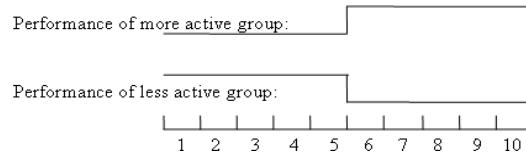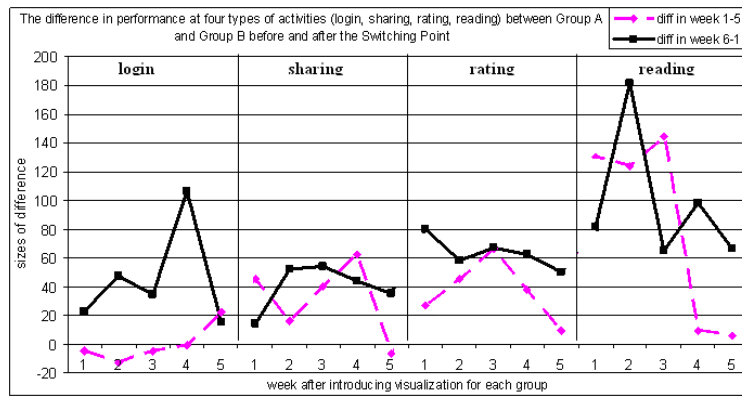

Fig. 7. Modified Experimental Hypothesis.

Fig. 8. Differences between the contributions of the two groups in the four activities.

Fig. 8 shows the differences between the contributions made by Group A – Group B for each week and for each type of activity. The X-axis is divided into four sections, each representing the difference in the performances in a particular type of activity (login, sharing URLs, rating URLs, or reading). Each section along the X-axis contains five segments, from 1 to 5, each segment representing a pair of weeks (Week 1 paired with Week 6 as marked by 1, Week 2 paired with Week 7 as marked by 2, Week 3 paired with Week 8 as marked by 3, Week 4 paired with Week 9 as marked by 4, and Week 5 paired with Week 10 as marked by 5). Thus, each point on the darker solid line is comparable to the point on the lighter dashed line. For example, the first point on the solid line represents the first week when Group B had access to the visualization and Group A did not, and the first point on the dashed line represents the first week when Group A had access to the visualization and Group B did not, and so on for the rest of the points. The solid line is mostly above the dashed line which indicates that most of the times the difference in the performances of the two groups after the switching point is bigger than it is before the switching point. This seems to confirm the modified hypothesis.

We performed two tests for statistical significance on the differences in each activity: t-test and the Wilcoxon's Matched-Pairs Signed-Rank Test. We found a significant difference in the performances of the two groups regarding the login and the rating activities. According to both the t-test and the Wilcoxon's test, the significance for logins is greater than 95%: the significance for rating is 97.5% according to the t-test, and 95% according to the Wilcoxon's test. However, the results for sharing and reading activities are weak. The t-test shows the probability of the difference in sharing activity being random is 29%, and the probability of the difference in reading activity being random is 33%.

The visualization had stronger motivational effect on Group B, the active group, than it had on Group A, the less active group. The reason why the active group was motivated more effectively is not clear. One possible explanation is that if a group is generally more active then the students in this group probably care more about their contribution levels and care if other users see them as good users or freeloaders.

The users provided qualitative feedback in the last two weeks of the term by filling in a questionnaire for which they received a bonus participation mark of 2% towards their final grade. A summary of the user answers to each question related to the visualization are presented below.

1. Please rank the following reasons for which you used the visualization
(1: most important; 5: least important):

	1	2	3	4	5
appears interesting	15%	20%	30%	20%	15%
find articles	10%	0%	20%	20%	50%
compare contributions	30%	35%	15%	5%	15%
check who contributed what	5%	20%	5%	35%	35%
find top contributors	15%	25%	30%	10%	20%

2. Please rank the following (from -2: "very poor" to +2: very good):

	-2	-1	0	1	2
overall	9%	0%	23%	59%	9%
support tool for the class cmpt408	9%	4%	13%	35%	39%
usability	11%	21%	21%	42%	5%
reliability (crashes etc.)	10%	19%	14%	43%	14%
visualization attractive	10%	5%	35%	30%	20%
visualization useful	10%	5%	35%	40%	10%
visualization intuitive	10%	15%	35%	25%	15%

visualization effective	25%	15%	40%	20%	0%
quality of shared links	20%	0%	25%	45%	10%
fairness	10%	0%	10%	65%	15%

Half of the subjects ranked "visualization attractiveness" as positive compared with the first design where only 34% of the subjects ranked this criterion positively and only 18% thought the first design "appeared interesting". 40% of the subjects thought the visualization was intuitive and 20% thought it was effective; however, the first design gave a slightly better result on the intuitiveness (48% positive ranking) than the final design. These numbers indicate that this version of the visualization is more successful in general compared with the first version.

3. What would be your reaction if you saw yourself as one of the smallest stars (regardless of its color and brightness) in the visualization?

 a. Take immediate action: share more links to make your star larger (20%)

 b. Think that you should probably share more links, but later (45%)

 c. Feel unhappy but do nothing (0%)

 d. Feel that the system is unfair, so it doesn't make sense to contribute (0%)

 e. Do not care, so will do nothing (20%)

 f. Other - please specify: (15%)

The data indicates that 65% of the users were motivated to contribute more if they saw their stars were not big enough in the visualization.

4. If you saw yourself as one of the largest stars (regardless of its color and brightness), would you:

 a. Feel proud of your status and try to contribute even more. (40%)

 b. Feel proud, but also in some sense "exploited", stop bringing more links. (10%)

 c. Feel worried, you may be raising the bar too high and the others may hate you or you may be perceived as "overachiever" by the others. (10%)

 d. Feel nothing, since it is not important for me. (35%)

 f. Other - please specify: (5%)

Most (55%) of the users were not motivated to contribute more once their stars are big enough in the visualization, and there is some discouraging factor as option b indicates.

5. Please rank the following factors according to how strongly they motivated you to contribute (1: strongest; 6: weakest):

	1	2	3	4	5	6
community visualization	8%	19%	19%	11%	8%	35%
earn higher membership	22%	19%	18%	15%	15%	11%

earn higher marks	43%	21%	4%	14%	11%	7%
bringing good papers	23%	12%	35%	11%	11%	8%
being best user	11%	28%	14%	18%	11%	18%
having best papers	11%	25%	18%	18%	18%	10%

The results show that a significant source of motivation is the social comparison, stimulated by the visualization. Forty-six (46%) of the subjects ranked the community visualization as strong motivator (1 to 3), 53% - being the best user, 54% - bringing the best papers, 59% - the status. Yet, there were other, stronger motivators - the expectation of receiving good marks was ranked as a strong motivator by 68% (these students are obviously extrinsically motivated), and bringing good papers was ranked as strong motivators (1 to 3) by 69% - students who seem to be intrinsically motivated.

6. Did you find the final visualization represents fairly your overall level of contribution in the class?

a. Yes (60%)

b. No (25%)

c. If No, why?

The justification given by the students who selected "b" above was based mainly on the dichotomy between quantity vs. quality of contribution. They thought there should be more emphasis given on the quality of the shared materials. 15% of the subjects were not sure about the overall fairness, and from the given justifications, we found this uncertainty was caused by unfamiliarity with the system.

6. Discussion

Comparing with the feedback from the case study of the previous design of the motivational community visualization (see Ref. 26, 27), these results show that users generally preferred the new design and found it more attractive. The feedback from the case study shows that a higher percentage of users (compared with the case study of the previous design) used the visualization to check who contributes how much and who the top contributors are. The new design of the visualization effectively motivated user contributions in each of the two groups A and B under the test condition. The experimental results confirm the hypothesis that the visualization helps shrinking the difference in the performances of the two groups when the less active group had access to the visualization and the more active group did not, and the visualization amplifies the difference in the performances of the two groups when the more active group had access to the visualization and the less active group had no access to the visualization. The motivational effect is more obvious on the active group than it is on the inactive group. The *t*-test and the Wilcoxon's Matched-Pairs Single Rank Sum test show that the difference in the performances of the two groups before and after the switching point is significant for login and rating activities but not for sharing and reading activities. To

conclude on each specific type of activity separately, the experiment needs to be run for a longer period of time, or we need to double the size of the experimental subjects so that we could run the experiment with two groups, one group with the visualization and the other group without, in parallel. Due to the limited class duration (12-13 weeks) the first option is not feasible, but increasing the number of subjects or running experiments in the same class under the same conditions for two consecutive years could be a direction of research.

The users generally found the new visualization design useful and interesting. The effect of the community visualization on motivating contributions and more active participation was shown in both case studies, but the significance of the effect is different depending on what is visualized, how it is visualized (i.e. what graphical representation is used), if it is easy enough for users to read and understand the visual representation (i.e. how intuitive the pictures are), and so on. The results indicate that the visualization is more effective on people who are naturally competitive and care about others' opinions and views on themselves. For people who are not competitive, sociable, or do not care about others' opinions on themselves, the visualization is not an effective motivator, since it was designed to facilitate social comparison. Competition [11,12] is a form of upward social comparison in which one compares and tries to "fit in" with the elite, top-performing sub-group.

One important conclusion is that the simpler the visualization is, the more predictable the effect is. As it was observed in the case study with the first design, users usually do not select any sorting criterion and rely on the default view, i.e. sorted by original contributions, so the node representing each user was only different in size. The nodes remained the same in color and there was no difference in brightness; even if users selected another sorting criterion, the visualization still visualized only one (the selected) criterion at a time. Therefore, the first design was one-dimensional visualization with the dimension determined by user's selection of the sorting criteria, which most of the times was "by original contribution" (the default view). The users related the size of their star with the number of their original contributions and this representation provided a clear direction for social comparison and improvement. That is why the first design was more effective in motivating original contributions, as the experimental results from the first study showed.

In comparison, the second design appears to be less effective than the first design in motivating user contributions in terms of original contributions (new shared papers / URLs). However, the second design was good in motivating diverse contributions, which is probably more desirable than one-dimensional contributions (just in one activity, sharing new papers). A complex visualization showing several dimensions at a time (e.g. size representing contribution level, color representing membership level, and brightness representing reputation level) is interpreted differently by users. Users can focus on different dimensions to compete, rather than one particular area of competition such as the number of contributions, so the motivational effect is dispersed to a variety of activities. If a longer time was available for the experiment and more data for analysis,

perhaps we would have seen a significant effect of the visualization on other user activities, i.e. sharing papers, and reading papers. One lesson learned is that when using more than one dimension (e.g. size, color, brightness) in the design, it is better to experiment on one dimension at a time, instead of testing all the dimensions at the same time. The experience from the two major experiments described in this thesis indicates that one-dimensional visualization is easier to be predicted and controlled because of less noise.

One clear conclusion for the designer is that when there is a clear goal about which type of contributions or participation is needed for the community, the visualization should represent just the user performance according to this type of participation or contribution. During the lifetime of an online community, different needs arise and different activities should be encouraged at different times [27] and so the default community view should be adapted to represent the activity that has to be encouraged at the moment.

7. Conclusions and Future Directions

Most visualizations discussed in the literature have been created with the purpose of informing the users about activities in the online community, since they allow a quick grasp of complex information. To our best knowledge, apart from a few works in the HCI area, presented in Section 2, and which focus mostly in information overload, there are no other visualizations specifically targeted at motivating user participation in the online communities.

This paper described the evolving design of the motivational community visualization targeted on encouraging participations in an experimental sharing community focusing on the last, most advanced design. The whole experience of developing this prototype visualization shows that it is not straightforward to create a motivational visualization. Apart from the great amount of information that needs to be represented, it has to be easy to operate, intuitive, attractive, and powerful enough to represent different semantics.

There are other interesting directions for further research, including the following:

1.   Dynamic adaptation of particular dimensions (e.g. different sorting criteria) that are visualized depending on what is needed mostly in the community (e.g. need more shared files, need better quality shared files, or need more people to rate or comment on the shared files).

2.   Exploring the impact on user participation of incorporating more semantics through new dimensions of the star metaphor that haven't been used so far: such as the distance between stars based on, for example, the similarity in taste or ratings given by users.

3.   Representing likeness between users, e.g. who reads whose contributions most often, who rates whose contributions most often, who normally rates whose contributions high and rates whose contributions low etc.

4.   Investigating the effects of different graphical representations of an online community. The proposed prototype of the visualization in this paper chose a specific metaphor, a staring sky, but there are alternatives, from simple representations such as

dots, circles, beehives, tables with numbers, charts, graphs, to complex metaphors such as cities, gardens, or combinations of any of the above. Which particular representation works best depends on the purpose of the visualization and the online community that it serves (e.g. the age of the members, their attitudes to computers, etc.) Investigating the effect of different metaphors for presenting community information is worthwhile.

5.   Creating a more advanced graphical representation, e.g. allowing the navigation in the cosmos, like in a 3-D game. For example, in the second design of the proposed prototype of the visualization interface, it might be possible to group users with similar interests into subgroups and visualize it by a galaxy, clicking on which will cause the expansion of this galaxy and displaying the inside view of this galaxy; or clicking on a star will navigate users to the group of friends of this star (based on what criterion to define a user is a friend of another user could be an interesting research topic), etc.

Acknowledgments

References

1.   Maslov A.H., "A Theory of Human Motivation", *Psychological Review* 50 (1943):370-96.
2.   Alderfer, C. "*Existence, Relatedness and Growth*", (New York: Free Press, 1972).
3.   McClelland, D. C.. *Power: The inner experience*. (New York: Irvington, 1975)
4.   Adams, J.S. "Inequality in Social Exchange" in *Advances in Experimental Psychology*, L. Berkowitz (ed.), (Academic Press, New York, NY, 1965), pp. 267-299.
5.   Skinner, B. "*Science and human behavior*". (New York: MacMillan, 1953).
6.   Gintis H., Bowles S., Boyd R., Fehr E. (2002) "Explaining altruistic Behavior in humans", *Evolution and Human Behavior* 24 (2003), pp.153-172.
7.   Harmon-Jones, E. "A Cognitive Dissonance Theory Perspective on Persuasion", The Persuasion Handbook: Developments in Theory and Practice, (Sage Publications: London, 2002), pp. 99-116.
8.   Booth-Butterfield, S. "Steve's Primer of Practical Persuasion and Influence", available online at: http://www.as.wvu.edu/~sbb/comm221/primer.htm.
9.   Cialdini, R.B. "*Influence – Science and Practice*", (Harper Collins Publishers: 1988).
10. Festinger L. "A Theory of Social Comparison Processes." *Human Relations*,**7** (1954), 117-140.
11. Garcia S., Tor A. "Rankings and Competition: Social Comparison in the Shadow of Standards", *Social Science Research Network Library*, 2005. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=880505#PaperDownload).
12. Suls, J., Martin R., Wheeler L. "Social Comparison: Why, with Whom and with What Effect?" *Current Directions in Psychological Science*, (Blackwell Publishers: 2002), pp 159-163. http://www.blackwell-synergy.com/doi/pdf/10.1111/1467-8721.00191
13. Beenen, G., Ling, K., Wang, X., Chang, K., Frankowski, D., Resnick, P. & Kraut, R.. "Using social psychology to motivate contributions to online communities." *Proc. of the ACM Conference on Computer Supported Cooperative Work (CSCW'04).* (ACM Press: NY, 2004). pp. 212-221.
14. Shepherd M.M., Briggs R.O., Reinig B.A., Yen J. and Nunamaker J.F., Jr. "Invoking Social Comparison to Improve Electronic Brainstorming: Beyond Anonymity". *Journal of Management Information Systems.* (1996), **12**(3), pp. 155-170.

15. Erickson, T. Kellogg, W. A., "Social Translucence an Approach to Designing Systems that Support Social Processes '" *ACM Trans. On Computer-Human Interaction*, 7 (1), 2000, pp. 53-83.
16. Smith, Marc and Andrew Fiore. "Visualization components for persistent conversations", *ACM SIG CHI* (2001), **3**(1), pp. 136-143.
17. Preece, J. (2000) Shaping Communities: Empathy, Hostility, Lurking, Participation. *Proceedings of CPSR DIAC2000*, Shaping the Network Society: The Future of the Public Sphere in Cyberspace, Seattle, pp. 25-34.
18. Ackerman M. and Malone T. "Answer Garden: A Tool for Growing Organizational Memory" Proc. Office Information Systems (1990) ACM: Cambridge, MA, pp 31-39.
19. Erickson T. "Designing Visualizations of Social Activity: Six Claims." Extended Abstracts of . *CHI'2003*, Ft. Lauderdale Florida, USA (ACM Press: NY, 2003).
20. Eick S. G. and Wills G. J. "Navigating Large Networks with Hierarchies". *Proc. Visualization '93*, (IEEE Press 1993). pp. 204-210.
21. Sprenger T. C., Brunella R., and Gross M. H. "H-BLOB: A Hierarchical Visual Clustering Method Using Implicit Surfaces". *Proc. 11th IEEE Visualization 2000 Conference* (VIS 2000) October 08 – 13, 2000. Salt Lake City, UT.
22. Pattison, T., Vernik, R., & Phillips, M. "Information Visualization Using Composable Layouts and Visual Sets". *Proc. Conferences in Research and Practice in Information Technology*, Vol. 9. Commonwealth of Australia, 2001.
23. Lamme, V. A. F. "Why Visual Attention and Awareness are Different". *TRENDS in Cognitive Sciences* **7**, 1 (2003), pp. 12-16.
24. Humphrey M. "Creating Reusable Visualizations with the Relational Visualization Notation" *Proc. 11th IEEE Visualization 2000 Conference* (VIS 2000). October 08 – 13, 2000. Salt Lake City, UT.
25. Bretzke H., Vassileva J. "Motivating Cooperation in Peer to Peer Networks", *Proc. User Modeling UM03*, Johnstown, PA, LNCS 2702, (Springer Verlag: Berlin – Heidelberg, 2003), pp. 218-227.
26. Sun, L., Vassileva J. "Social Visualization Encouraging Participation in Online Communities", *Proc. 12th International Workshop on Groupware CRIWG'2006*, Medina del Campo, LNCS 4154, (Springer Verlag: Berlin-Heidelberg, 2006), pp.349-363.
27. Vassileva J., Sun L. "Using Community Visualization to Stimulate Participation in Online Communities" *e-Service Journal*, **6** (1), pp.3-40. Special Issue on Groupware.
28. Cheng R., Vassileva J. "Design and Evaluation of an Adaptive Incentive Mechanism for Sustained Educational Online Communities". *User Modeling and User-Adapted Interaction*, , **16** (2/3), 2006, pp. 321-348.