Peer-to-Peer Valuation as a Mechanism for Reinforcing Active Learning in Virtual Communities: Actualizing Social Exchange Theory

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Abstract

As knowledge becomes the primary focus of work in many industries, virtual communities and groups are emerging as part of new organizational forms. Within these virtual forms, efficacy of learning in group problem solving and knowledge sharing tasks is influenced by factors such as the level of participation and domination, the level of consensus and cooperation, and satisfaction with group processes. Active collaborative filtering, however, is limited in its ability to motivate active participation. Further, literature reports that virtual discussions are frequently faced with the 'cold-start' problem. In this paper, we apply Social Exchange Theory as a foundation to address these limitations. We posit that by applying the insights provided by Social Exchange Theory, member perceptions of the costs and benefits of participating in the virtual group can be modified over time. By providing active feedback to each member, we can influence his/her behavior and willingness to contribute. We propose a modified architecture for virtual community discussions, and demonstrate both the viability and implementation of this as a Web-based system with the initial version of a prototype that actualizes Social Exchange Theory to encourage active learning and knowledge sharing in a peer-to-peer community.

1. Introduction

As knowledge becomes the primary focus of work in most industries [1, 2] organizations have started restructuring themselves around cross-functional and trans-organizational communities. These communities are often geographically distributed and are constituted of groups of knowledge workers who bring their own assumptions, expertise, skills, biases, intuition, experience, and knowledge to solve the problem at hand [3]. This paper builds upon the philosophical assumption that virtual work is made possible by the electronic networks, in the form of Intranets, electronic mail, and group systems, that can be enhanced by an understanding of their characteristics that enable sharing and transfer of knowledge, as *perceived* by participating virtual workers.

Efficacy of learning in virtual group problem solving and knowledge sharing tasks is influenced by three factors identified from extant collaborative filtering and organizational learning literature: (1) level of participation, (2) level of consensus and cooperation, and (3) satisfaction with group processes. Lacking such satisfaction, group processes will result in poor outcomes. Social Exchange Theory [4], which suggests that participants in a peer-based community expect mutual reciprocity, provides the theoretical foundation for this research.

To examine how Social Exchange Theory can be actualized in virtual communities and work groups, we begin with a review of relevant literature from theoretical streams in computer supported collaborative work, collaborative filtering, communities of practice, knowledge management, Social Exchange Theory and organizational learning. We identify factors that affect learning and knowledge sharing in such communities and interpret determinants of the efficacy of collaborative filtering mechanisms in light of Social Exchange Theory. We propose an architecture for a virtual conversing tool that takes these differences into account and encourages active participation by community members. Based on these interpretations, we demonstrate how Social Exchange Theory can be used to support active learning using a Web-based system prototype.

2. Web-based Virtual Communities

Communities are described as social groupings that exhibit in varying degrees: shared spatial relationships, social conventions, a sense of membership and boundaries, and an ongoing rhythm of social interaction [5, 6]. The Web is increasingly being used as a collaborative medium to connect and link people across organizational, temporal, and geographic boundaries. Tacit knowledge is a personal resource, yet researchers have found that teams as well as organizations can be "usefully thought of as possessing knowledge that has

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characteristics of tacit knowing" [7]. Tacit knowledge exists within communities and groups in the form of shared practices [7] and relationships that emerge from working together over a period of time. This results in the creation of the social fabric that connects communities of knowledge workers [8]. Wenger suggests that a person reveals his competencies and interests through his behavior in group activities (such as discussions) [9]. In virtual communities, mappings and strengths of affiliations can be determined by expressions of belongingness as exhibited by contribution to the community, a sense of membership and common history, and "bleeding" across similar community boundaries [10]. By participating in communities, such a person also identifies oneself with communities to which he/she belongs. From a philosophical standing, this paper takes a social constructivist viewpoint and examines information technology enablers of such communities, specifically those built on the World Wide Web infrastructure. When an information technology system is viewed as an enabler of virtual community formation, Social Exchange Theory provides a rich basis for further analysis.

2.1. Research Questions

This paper addresses two research questions:

1. How can Social Exchange Theory be actualized to reinforce active learning and knowledge sharing in highly distributed virtual groups and communities?
2. What are the implications of this theory on the design or redesign of collaborative technology systems used to build such communities? Further, what technology architecture is needed to realize this?

To that end, we propose actualization of Social Exchange Theory through a proof-of-concept system that will encourage knowledge sharing and reinforce active learning in such communities. Further, it will provide a measure that will allow each member of the virtual community to judge his/her contribution to the community in *relation* to that of the group as a whole.

3. Social Exchange Theory

Social Exchange Theory [4] provides well-developed and generalizable insights into processes influencing the maintenance of relationships in social settings such as task groups and virtual communities. Social Exchange Theory suggests that there is a relationship between a person's affect (satisfaction with a relationship) and his commitment to the relationship. Thibaut and Kelly [4] indicate that it is possible for a person to be satisfied with a relationship but not committed to it, or committed to a relationship but not satisfied with it.

We apply Social Exchange Theory in group settings that are centered around virtual communities of practice. The standards on which relationships within a virtual community of knowledge workers are evaluated are defined by two factors: the comparison level (CL) and the comparison level of an alternative relationship (CL^{alt}). CL is defined as the standard against which the participant evaluates the attractiveness of a relationship or level of satisfaction with an existing relationship, as *perceived* by him. Similarly, the comparison level of an alternative (CL^{alt}) is defined as the lowest level of outcomes a person will accept in light of available, attractive, alternative opportunities in other relationships (such as not participating in problem solving discussions, in our case). Thibaut and Kelly [4] suggest that the participant becomes progressively more dependent on the relationship as outcomes in a current relationship exceed CL^{alt} by increasingly larger degrees. Social Exchange Theory, as proposed by Thibaut and Kelly [4], has been further extended (see [11]) to include the concept of investment of resources such as time, money, energy etc that an individual has invested in the relationship. The purpose of these extensions was to predict the degree of commitment to, and satisfaction with ongoing relationships. Rusblut and Farell [11] postulate that such investments will be lost if the relationship ends. They further suggest that a person's commitment to a relationship is defined by a simple function:

$$\{\textbf{Commitment to relationship} = f\,(\mathbf{CL - CL^{alt}})\}$$

The above relationship therefore suggests that high investments and poor alternatives may keep a participant in a community even if the relationship is dissatisfying. On the corollary, a person might have a high level of commitment to an existing relationship when satisfaction is high and attraction (indicated by CL^{alt}) is low [4, 11]. In the context of virtual communities, such investments might include resources such as time, money and energy invested in the relationship that evolves with the rest of the group [11].

3.1. Determinants of Efficacy of Learning

Virtual communities are unstable entities often characterized by high membership fluidity. As such communities devolve and are reconstituted over time, the collective synergy and shared understanding that its members achieve over time can be lost [12]. Group success is critically dependent on effective knowledge sharing among members [13]. Research suggests that efficacy of learning, active involvement and knowledge sharing in communities and virtual groups critically hinges on three factors:

1. *Level of participation and domination* [14-16]. Level of participation, in this context, refers to the extent to

which members of the virtual group actively engage in ongoing activities of the group, such as discussions.

2. *Level of consensus* between and domination among members [15].

3. *Satisfaction with group processes.* Research in group literature (e.g. [17, 18]) suggests that increased satisfaction with group processes is consistent with findings of higher consensus, better decision quality, higher confidence in decisions made by peers, increased overall satisfaction, and increased participation [15].

3.2. The Role of Conversations

Schein [19] suggests that learning in groups takes place through conversation. He suggests that work groups, in this case virtual communities, need to understand the essence of the problem or task at a level that is sufficient to begin a conversation. As explained in Figure 1, such conversations lead to deliberation characterized by lack of understanding, disagreement, personal evaluations of choice, and strategy. He further classifies two parallel streams of activity that emerge from such deliberations: suspension (accepting differences and building mutual trust) and discussion (advocacy, competition, and convincing efforts). This further leads to dialog and dialectic where group members confront each others assumptions, build common ground, and explore oppositions, which in turn leads to metalog where the group, as a whole, builds new shared assumptions and resolves the problem by logic and debate. Adopting these ways of conversing to virtual media (such as discussion groups), we have a beginning point for building support mechanisms for such conversations in virtual space.

By allowing users to provide proxy valuation through perceived value (usefulness and relevance) ratings to member postings, we will be able to support an ongoing dialog within the virtual community.

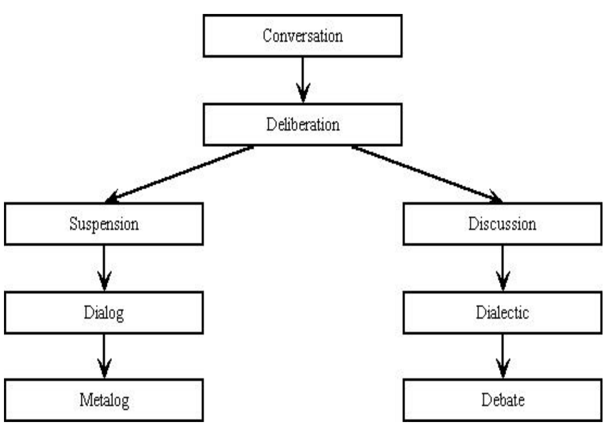

Figure 1: Conversations in communities and work groups – an opportunity for learning

3.3. The Web as an Enabler

The World Wide Web provides the platform for linking and connecting distributed members to form a community in virtual space. Members can share pointers, documents, and unstructured content as shown in Figure 2. P(1) through P(*n*) constitute the set of *n* members that form the community. Each of these is connected to a common space on the Web, therefore linked to each other. Indirect feedback loops exist throughout the community as messages and responses are posted to this common space. Members can share structured and unstructured documents, files, multimedia content (such as pictures, sound files etc.), engage in discussions, and retrieve other members' contributions through collaborative filtering software and push delivery mechanisms. For this paper, we have limited the scope of such collaboration to discussions—which might be for collaborative problem solving and/or knowledge sharing.

Nonaka and Takeuchi [20] identify four processes that underlie organizational knowledge creation and learning: (1) development and creation of new knowledge, (2) securing and organizing both new and existing knowledge, (3) distribution of knowledge, and (4) combination of available knowledge. Creation and development of knowledge requires proactive identification of desired content and involvement of people to contribute ideas through on-line discussions [21] and documentation of completed work [21, 22]. Securing and organizing knowledge requires tools such as repositories and navigational devices within which content is arranged using applicable taxonomies [21]. Apostolou and Mentzas [21] suggest that retention of currency and design of the interface are critical aspects on which the process of organization depends. While repositories can handle explicit knowledge in an effective manner, tacit components of knowledge do not lend themselves to such formalization [23]. Extant literature suggests that incorporation of multimedia support and pointers to tacit knowledge resources (such as people) can help overcome such limitations to a limited extent [21-23]. Such knowledge maps provide pointers to people, documents, and records that can direct users to resources that contain such tacit knowledge [21]. Stein and Zwass [24] contend that this categorization does not provide the right level of abstraction for formulating requirements for organizational memory implementations since they are not directly related to goals of the organization or the work group.

Contingency theorists have long argued that technical systems predispose organizations to particular structures. Barley (1986) has modified this viewpoint using an expanded notion of social structure that contrasts with the static organization chart type images of contingency and social impact models. Dubinskas [25] further expands on

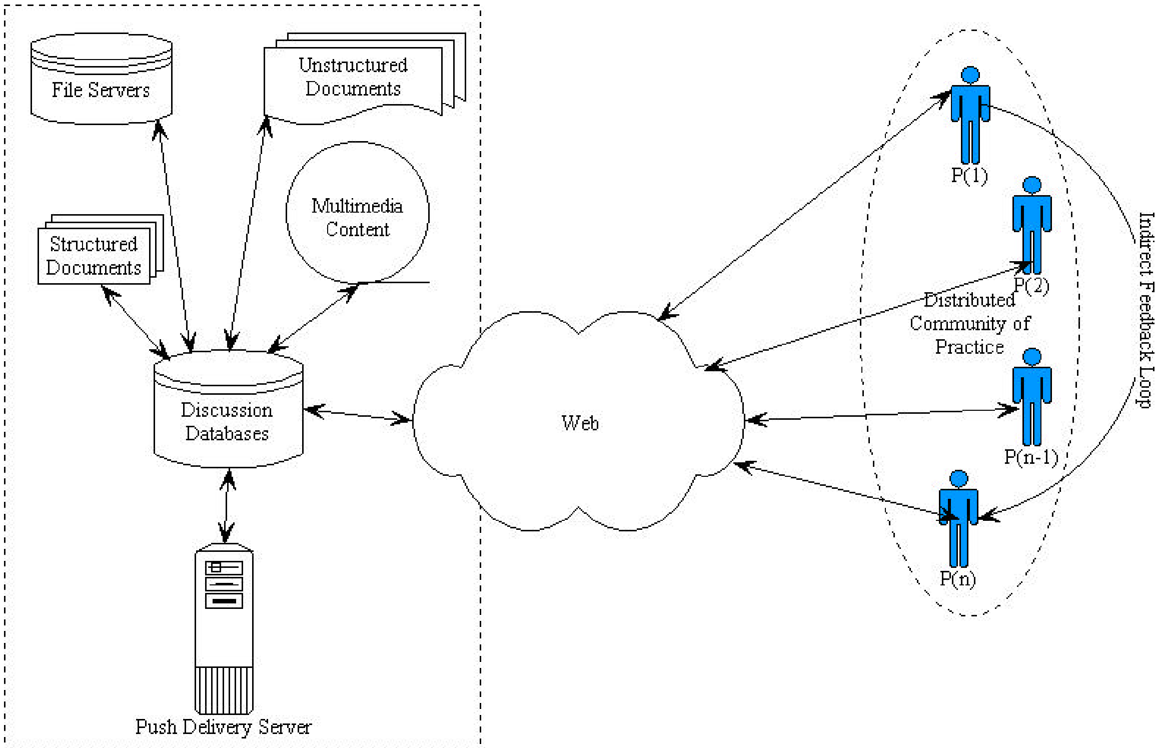

Figure 2: Virtual communities and their technological enablers

this literature base to suggest that technology becomes an occasion for structuration, and that organizational relationships and practices are reshaped in synchrony with dynamics of the social process. Technologies, such as those used to enable distributed teamwork, are socially constructed and these technical systems embody social knowledge, processes, and outcomes [25]. Using a social constructivist lens, Sillince and Mouakket [26] use 'emancipatory effects' to describe the locus of knowledge in groups connected through information technology. Therefore, social aspects of virtual communities need to be taken into account while designing technology networks such as discussion forums for collaborative communities.

4. Research on Collaborative Filtering

Information filtering [27] is constituted of three filtering activities: cognitive filtering, economic filtering, and social filtering. Cognitive filtering focuses on content, economic filtering focuses on perceived costs and benefits, and social filtering focuses on quality judgments as communicated through personal relationships. Our work focuses on cognitive and economic filtering, with some overlapping aspects integrated from social filtering. Social filtering inspired further work in collaborative filtering and community centered collaborative filtering, which we discuss next.

Research on collaborative filtering (as defined by [27]) addresses and incorporates the significance of social networks in virtual groups. Collaborative filtering refers to "sharing of knowledge through recommendations" [10]. The concept of collaborative filtering emerged from the Information Tapestry project at PARC [28]. Tapestry allows users to add annotations to documents that they read online. By allowing such contextual additions, the system allows users to pass judgments on the value of documents that they read. This work, further, led to the development of Pointers by Lotus [29].

Tapestry was followed by GroupLens [30]. This system allows communities of users to rank the articles that they read on a numerical scale, thereby combining collaboration with user profiles. As users rank articles and posts on a numerical scale, the system finds correlations between the ratings that different users have given to a post or an article set. These systems suffer from a cold start problem i.e. without a critical mass of users the aggregates calculated are meaningless. They also suffer from excessive overhead in either registering a vote, accessing the result of other people's votes, or creating a profile. GroupLens has been a victim of the issue that this paper addresses. As the authors suggest in their set of limitations [30]:

> "…Many users abandon the system before ever receiving benefits from it because they perceive effort without reward."

They also point out the problems emerging from the unwillingness of users to spend time rating posts and articles, especially in the early stages of adoption. Active collaborative filtering takes the idea of collaborative filtering one step further by allowing users to share pointers, ideas, and opinions. Recommendations indicate user preferences [27] and statistical learning algorithms refine the system's understanding of user preferences by tracking usage and user behavior. A summary of these systems, as shown in Table 1, illustrates that all of these are victims of their own design by failing to provide sufficient incentive for users to rate every post that they read. Applying Social Exchange Theory, this perception can be modified over time and users can be provided statistically aggregated feedback on their contribution to their community in comparison to that of the average member's.

Table 1: Limitations of previous virtual community support systems

System	Description	Limitations
Tapestry [28]	Recommend-ations on top of email and usenet groups	Cold-start problem. Unwillingness to rate Perception of insufficient rewards.
Pointers [29]	Commercial version of the above	Cold-start problem. Unwillingness to rate Perception of insufficient rewards.
GroupLens [30]	News groups only; community centered collaborative filtering	Perception of insufficient rewards when compared to costs/ investments. Users tend to abandon the system at early stages. Requires critical mass of users to be meaningful.

5. Actualizing Social Exchange Theory in Virtual Communities

Social Exchange Theory has been applied in a variety of disciplines and contexts such as personal relationships, employee retention, and labor law. Since organizational structures, enabled by information technology and provoked by globalization, are taking on an increasingly distributed form, we have applied Social Exchange Theory to communities of such knowledge workers. In this context, communities of knowledge workers are a specialization of virtual communities of practice [9].

As Thibaut and Kelly [4] suggest, workers will actively contribute and participate in a community if the level of satisfaction with the processes within such a community, as perceived by them, is high. In specific instantiations of this theory, literature suggests three possible reasons that could underlie the motivation and commitment of community members to their communities.

1. *Anticipated reciprocity*: The participant is motivated to contribute valuable information to his community with a pre-existing expectation that he will receive actionable and useful information in return. Actionable information has also been appropriately defined as knowledge [22, 23, 31]. Such reciprocity might occur as generalized exchange within the group as a whole [32]. Reciprocity within a community, such as one centered on a corporate discussion group, allows members of the community to draw upon each other's knowledge contributions without having to reciprocate contiguously [32].
2. *Reputation and influence within a community:* Rheingold [6] suggests that the effect of one's contributions based upon his reputation within the community can also influence, both positively and negatively, his willingness to share relevant knowledge with other members of the community. He also cites specific examples of factors that can increase a contributor's reputation within his community: high quality information, impressive technical details in one's answers, willingness to help others, and elegant writing etc. In line with Kollock's [32] observations, the effects of such relevant knowledge contributions/sharing acts are likely to be seen by the community as a whole [6].
3. *Perception of efficacy:* Members are more likely to exert greater effort if one or more of three conditions apply: (1) their contributions are identified as being important, (2) contributions are personally relevant, and (3) members perceive a clear relationship between contribution and outcome [33]. Another reason that can explain the motivation of a community member to contribute to a group process is a perception of efficacy, as suggested by Bandura [34]. This perception of efficacy is defined as a community member's belief that his regular, quality contributions have an impact on his community as a whole [34]. It has been further suggested [34] that such contributions add to the contributor's reputation within the community, as postulated above, in our second reason for commitment.

5.1. Shaping User Perceptions over Time

Glance et al. [35] suggest that user perceptions of costs and benefits of engaging in a collaborative effort (such as within a virtual community) over time can be very different from one-shot costs and benefits. Based on this finding, we expect users to participate in discussions that already have a high level of activity. Providing feedback to members should cause them to consider their contribution over time and modify their perception of costs versus benefits of participating. We expect this to result in better alignment between average community wide and user specific activity, as demonstrated by the follow up empirical validation that we will conduct.

6. Mapping Systemic Requirements

Based on our preceding discussions on mechanisms influencing knowledge sharing and knowledge creation within communities of practice, we suggest mappings between social exchange driven motivations and technology enablers to *satisfice* [36] them. We further translate these technology characteristics into system characteristics to arrive at specifications for our community centric peer-to-peer valuation prototype, as shown in Table 2. Such translations are necessary to establish a link between information technology components and organizational goals [24]. The scope of our prototype is restricted to collaborative communities that are physically distributed and linked through a rich communications medium such as the Web, which is used as an example in our study.

Table 2: Mapping Social Exchange Theory based motivations to system characteristics

Characteristic/ knowledge sharing motivators based on Social Exchange Theory	Technology Enabler(s)	System Characteristic
Anticipated reciprocity	Provide feedback on average contributions and retrievals that each user engages in, over a time frame such as a week.	Show average contributions and benefits per user, graphically compared to that of the individual user.
Reputation and influence within a community	Allow contributors to (optionally) identify themselves.	Contributors are identified with each rating and/or contribution.
Perception of efficacy	Show the effects of a member's contribution to the overall activity in the community.	Average posts and responses for each user are compared to an aggregated percentage in a browser window frame.

7. Supporting Collaboration in Virtual Groups

We have designed a Web-based prototype to support collaborative exchanges among virtual groups. Drawing on Social Exchange Theory, this prototype incorporates iterative feedback to members of the virtual group in two ways. First, members can judge their individual levels of participation in comparison to the average group member's participation. Second, members can assign values to individual messages yielding an overall group average value. This minimizes process losses arising from social loafing that otherwise threaten the quality and quantity of individual contributions [37]. These features represent an extension to traditional online discussion group forums that offer no mechanisms for assessing contributions or perceived value.

7.1.1. Extending on-line discussion groups. On-line discussion groups take on a variety of forms. Some are implemented as listservs where members conduct discussions via email. Others are Web-based, incorporating hyperlinks for threaded discussions. Interaction in these on-line discussions is limited to posting and replying to messages. In this environment, there is no explicit relative value assigned to messages.

7.2. Architecture

Turoff [38] discusses how the Web has enabled virtual systems that in turn create new social systems. This evolving virtuality has progressed through stages one and two, and currently resides in stage three (Table 3) [38].

Table 3: Stages of virtuality

Stages	Description	Characteristics
1	Technological Progress	Computers will have long-term impacts on social systems at all levels.
2	Social System Design	Designs of human communication systems operating in virtual, computer enabled communities are new social systems that are real to their users.
3	Control System Design	The computer as part of this new real world can be used as a control system.

The architecture (Figure 3) of our Web-based prototype incorporates elements of control into the system that supports virtual group collaboration.

We designed our prototype with the user's needs as a primary requirement. As such, we chose a Web client for its portability, familiarity, and ease of use. Our system is non-intrusive i.e. it facilitates the user's interactions but does not imposingly interfere. We have allowed members to remain anonymous to the group but not anonymous to the system. Our prototype focuses on the community not the individual. Member screens are individualized only to the extent that they show the individual's contributions relative to the group. Finally, we have incorporated a benefit mechanism for members in the form of ratings assigned to posts by members of the group.

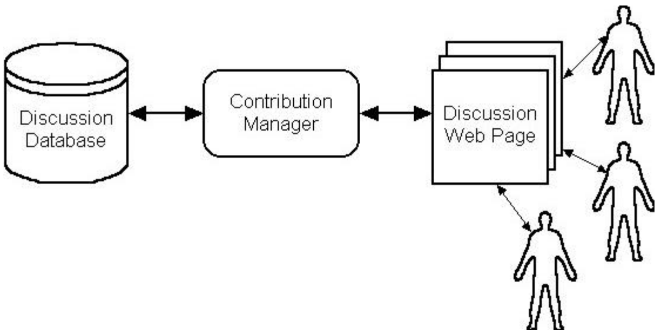

Figure 3: An architecture for the proposed Web-based prototype

The architecture consists of three primary components: the Discussion Web Page, the Discussion Database, and the Contribution Manager.

7.2.1. Discussion Web page. The interface with each member of the virtual collaborative group is the Discussion Web Page. Each member of the group views a personalized, dynamically generated Web page that contains two main parts (Figure 4). First, the member views threaded discussions along with the average ratings assigned to each message by the group. Second, the member views his average number of new posts per time period and his average number of responses per time period, both compared to the group averages per time period for each category.

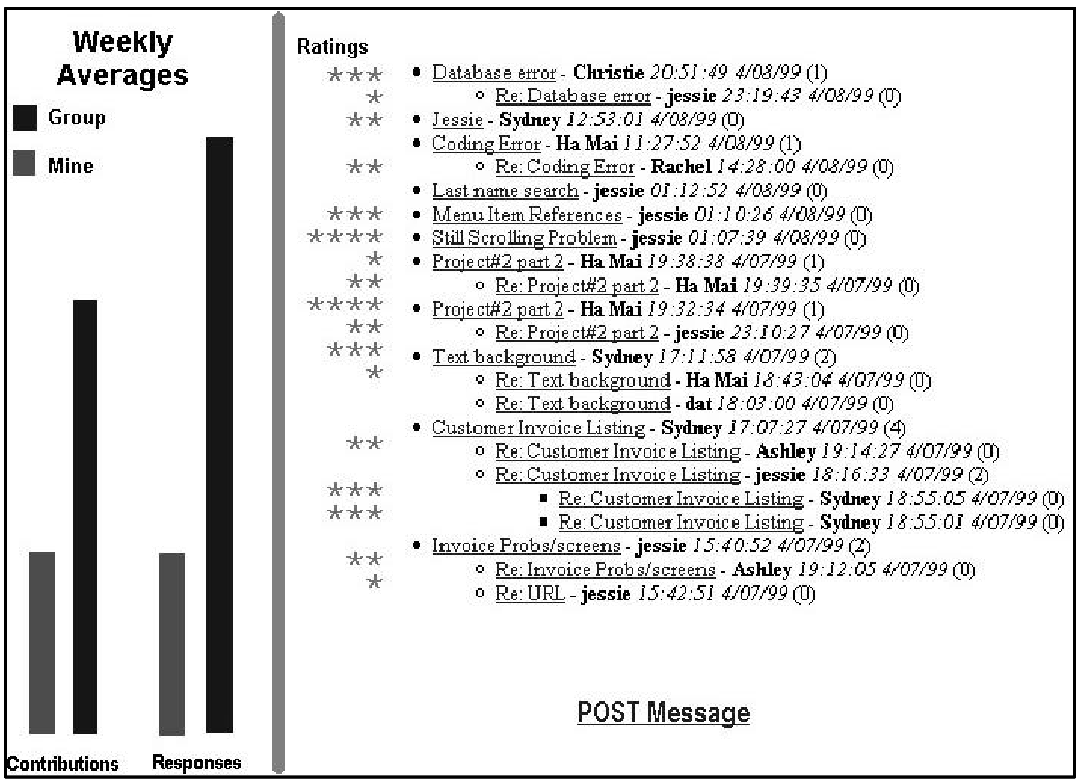

Figure 4: The Web-based prototype front-end

From the main discussion Web page, members can access a secondary Web page by activating a hyperlink within the threaded discussion. This page provides a mechanism for both replying to and rating a message based on individual judgments.

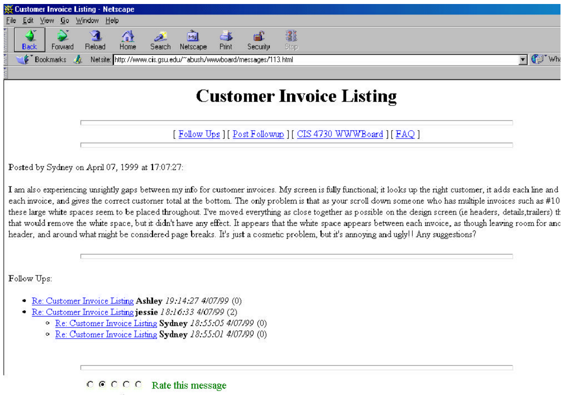

Figure 5: Each message or post can be rated on a normal scale of 1 through 5

7.2.2. Discussion database. The Discussion Database is the central repository for messages and ratings. Figure 6 illustrates the contents of the database.

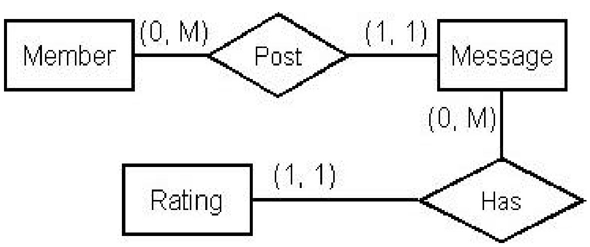

Figure 6: Database structure

Within the database, Member contains information to uniquely identify the members of the virtual collaborative community. Only members with valid IDs and passwords are permitted to participate in the discussion. This information allows the Contribution Manager to track an individual's contributions to the group. While the identity of the members is tracked in the database, individuals are allowed to post messages under a pseudo-name, but their Web pages will always display their current contributions.

Message contains information on all messages and responses including the text of the message, and the date and time of posting. A unique message ID and member ID that indicates the identity of the member who posted the message are assigned to each message.

Finally, Rating tracks the ratings assigned to each message by the members of the virtual collaborative community. Message IDs and member IDs combine to uniquely identify these ratings. Each member can only rate each message one time.

7.2.3. Contribution Manager

The main function of the Contribution Manager is to dynamically generate a customized member Web page. An integral part of this function is the calculation of member contributions. When a member enters the virtual collaborative community, a customized, dynamically generated Web page is displayed. Dynamic generation is required because other members are able to continually post contributions to the community that are subsequently stored in the database. Hence, the dynamically generated pages are updated with the most current contributions from the database.

Dynamic generation also allows real-time calculation of the member's contributions. This is the mechanism for providing active feedback to the members of the group. The feedback provided to each member is average contribution per time period and average responses per time period. Each average is calculated based on a specified time period (day, week, month) and compared to the group average for both contributions and responses for the same period. This information is graphically represented for the member in the left frame of the Web page.

Another benefit of dynamic generation is the automatic display of the calculation of average message ratings. These ratings are calculated for each message (or response) that has been rated by at least one member. Average ratings are displayed next to the message in the right frame of the Web page.

8. Empirical Validation

There are three distinct phases that constitute our research project: Development of a theoretically grounded prototype, a laboratory experiment to validate the prototype, and a field test to evaluate its efficacy. The prototype system design has been completed and its implementation is in progress. Validation of the prototype will be conducted as a laboratory experiment with two alternative approaches for empirical validation. The first approach will utilize a questionnaire to measure member perceptions of participation. The second approach will manipulate the feedback provided to the individual members. Both approaches assume groups with active, 'non-lurking' members. Effectiveness can also be alternatively tested by observing system usage through the lenses of expectancy theory and equity theory.

8.1. Questionnaire

The laboratory experiment will consist of a control group and an experimental group. The control group will engage in a virtual collaborative discussion using a 'traditional' discussion group format (i.e. no active feedback on contributions, responses or ratings.) The experimental group will engage in the same virtual collaborative discussion but will use the prototype and receive active feedback on contributions and responses. This group will be allowed to rate messages. At the end of the discussion period, the control group will complete a questionnaire to assess their perceptions of their own and the group's level of contributions and responses. Perceptions of participation will be evaluated against actual levels of participation.

8.2. Manipulation of Feedback

For the manipulation of feedback alternative, both the control and experimental groups will engage in the same virtual collaborative discussion using the prototype system as developed with the elements of active personalized feedback and member ratings of messages. The control group will participate without any manipulation. The active feedback of the experimental group will be manipulated. Group average contributions and responses will be altered to reflect a lower level of participation on the part of the members. Subsequent analysis will measure whether the experimental group contributed and responded at a greater level than the control group. This analysis will show whether the prototype with active feedback influences member participation.

9. Limitations

There are three primary limitations of this prototype: the assumption of non-lurking group members, scalability to larger groups, and limited anonymity. One characteristic of discussion groups is the presence of lurking group members. These members visit the discussion group to read messages but do not participate in the discussion. They take but they do not give. Our prototype assumes non-lurking group members. All members participate in the discussion on some level by posting messages, replying to messages, and assigning ratings to messages.

Since the prototype dynamically generates customized Web pages to provide active feedback to the members, scalability to large, extremely active groups becomes a limitation. At present, the prototype is capable of supporting relatively small groups with membership up to a few hundred people.

As previously discussed, members of the group can post and reply to messages anonymously if they wish. Rating of messages is also an anonymous process. While anonymity is present on the front-end, the database actually tracks the member's posts and ratings. On the part of the member, there is only a perceived anonymity.

10. Contributions

The contribution of this work is the actualization of Social Exchange Theory in virtual collaborative Web-based communities. This falls into stage three of Turoff's [38] characterization of evolving virtuality. In stage three, the computer is used to control the social systems that have become real to the user group. In our prototype, the active feedback presented to the members of the virtual community represents a control mechanism of the social system created within the virtual community. Based on Social Exchange Theory, active feedback encourages knowledge sharing within the group and increases member participation. The prototype uses peer-to-peer valuation to change the perceived value of a member's contribution to the group as a whole. The implication of this is that members who have low rated contributions will eventually drop out of the group leaving a group with a higher overall perceived contribution value.

We have demonstrated, using an initial version of a Web-based prototype, how peer-to-peer valuation can be used to change the perceived value of a member's contribution to the community as a whole. We expect our empirical validation to lend further support to this claim. We have also proposed an architecture to guide such an implementation.

The present system limits its scope to discussions and conversations in virtual communities. Future work needs to address incorporation of additional data types and multiple modes of informal communication among community members.

11. References

[1] Davenport, Jarvenpaa, and Beers, "Improving Knowledge Work Processes," *Sloan Management Review*, pp. 53-65, 1996.

[2] P. Drucker, *The Post Capitalist Society*, First ed. New York, NY: Harper Business Press, 1993.

[3] C. Ciborra, *Teams, Markets, and Systems: Business Innovation and Information Technology*. Cambridge [England]; New York: Cambridge University Press, 1993.

[4] J. Thibaut and H. Kelley, *The Social Psychology of Groups*. New York: Wiley, 1959.

[5] F. Hesselbein, *The Community of the Future*, 1st ed. San Francisco: Jossey-Bass, 1998.

[6] H. Rheingold, *The Virtual Community: Homesteading on the Electronic Frontier*. New York: Addison-Wesley, 1993.

[7] C. Choo, *The Knowing Organization*. New York: Cambridge University Press, 1998.

[8] J. D. Brown, "Organizational Learning and Communities of Practice: Towards a Unified View of Working, Learning and Innovation," *Organization Science*, vol. 2, pp. 40-57, 1991.

[9] E. Wenger, *Communities of Practice: Learning, Meaning, and Identity*. New York: Cambridge University Press, 1998.

[10] H. Kautz, B. Selman, and M. Shah, “Referral Web: Combining Social Networks and Collaborative Filtering,” *Communications of the ACM*, vol. 40, pp. 63-65, 1997.
[11] C. Rusbult and D. Farrell, “A Longitudinal Test of the Investment Model: The Impact on Job Satisfaction, Job Commitment, and Turnover of Variations in Rewards, Costs, Alternatives, and Investments,” *Journal of Applied Psychology*, vol. 68, pp. 429-438, 1983.
[12] A. Inkpen, “Creating Knowledge through Collaboration,” *California Management Review*, vol. 39, pp. 123-140, 1996.
[13] A. Townsend, S. DeMarie, and A. Hendrickson, “Virtual Teams: Technology and the Workplace of the Future,” *Academy of Management Executive*, vol. 12, pp. 17-23, 1998.
[14] M. Turoff and S. Hiltz, “Computer Support for Group versus Individual Decisions,” *IEEE Transactions on Communications*, vol. 30, pp. 82-90, 1982.
[15] K. Kraemer and A. Pinsonneault, “Technology and Groups: Assesment of the Empirical Research,” in *Intellectual Teamwork*, J. Galegher, R. Kraut, and C. Egido, Eds. Hillsdale, N.J.: Lawrence Erlbaum and Associates, 1990, pp. 375-405.
[16] G. DeSanctis and R. Gallupe, “A Foundation for the Study of Group Decision Support Systems,” *Management Science*, vol. 33, pp. 589-609, 1987.
[17] J. Nunamaker, L. Applegate, and B. Konsynsky, “Facilitating Group Creativity: Experience with a Group Decision Support System,” *Journal of Management Information Systems*, vol. 3, pp. 6-19, 1987.
[18] R. Steeb and S. Johnson, “A Computer-based Interactive System for Group Decision Making,” *IEEE Transactions on Communications*, vol. 11, pp. 544-552, 1981.
[19] E. Schein, “On Dialogue, Culture and Organizational Learning,” *Organizational Dynamics*, pp. 23-29, 1993.
[20] I. Nonaka, “The Knowledge Creating Company,” *Harvard Business Review*, pp. 2-9, 1991.
[21] D. Apostolou and G. Mentzas, “Managing Corporate Knowledge: A Comparative Analysis of Experiences in Consulting Firms,” presented at Second International Conference on Practical Aspects of Knowledge Management, Basel, Switzerland, 1998.
[22] I. Nonaka and H. Takeuchi, *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*. New York: Oxford University Press, 1995.
[23] T. H. Davenport and L. Prusak, *Working Knowledge : How Organizations Manage What They Know*. Boston: Harvard Business School Press, 1998.
[24] Stein and Zwass, “Actualizing Organizational Memory with Information Systems,” *Information Systems Research*, vol. 6, pp. 85-117, 1995.
[25] F. Dubinskas, “Virtual Organizations: Computer Conferencing and Organizational Design,” *Journal of Organizational Computing*, vol. 3, pp. 389-416, 1993.
[26] J. A. A. Sillince and S. Mouakket, “Varieties of Political Process during Systems Development,” *Information Systems Research*, vol. 8, pp. 368-397, 1997.
[27] T. Malone, K. Grant, F. Turbak, S. Brobst, and M. Cohen, “Intelligent Information-sharing Systems,” *Communications of the ACM*, vol. 30, pp. 390-402, 1987.
[28] D. Goldberg, B. Oki, D. Nichols, and D. Terry, “Using Collaborative Filtering to Weave an Information Tapestry,” *Communications of the ACM*, vol. 35, pp. 61-70, 1992.
[29] Lotus, “Pointers,” vol. 1998: Lotus Development Corporation, 1997.
[30] J. Konstan, B. Miller, D. Maltz, J. Herlocker, L. Gordon, and J. Riedl, “Recommen-sys: Applying Collaborative Filtering to Usenet News,” *Communications of the ACM*, vol. 40, pp. 77-87, 1997.
[31] D. Leonard-Barton and S. Sensiper, “The Role of Tacit Knowledge in Group Innovation,” *California Management Review*, vol. 40, pp. 112-131, 1998.
[32] P. Kollock, “An Eye for an Eye Leaves Everyone Blind: Cooperation and Accounting Systems,” *American Sociological Review*, vol. 58, pp. 768-786, 1993.
[33] J. Shepperd, “Productivity Loss in Performance Groups: A Motivation Analysis,” *Psychological Bulletin*, vol. 113, pp. 67-81, 1993.
[34] A. Bandura, “Self-Efficacy in Changing Societies,” Cambridge: Cambridge University Press, 1995.
[35] N. Glance, T. Hogg, and B. Huberman, “Training and Turnover in the Evolution of Organizations,” *Organization Science*, vol. 8, pp. 84-96, 1997.
[36] H. Simon, *The Sciences of the Artificial*, 2nd ed. Cambridge, MA: MIT Press, 1981.
[37] J. Nunamaker, A. Dennis, J. Valachich, D. Vogel, and G. J., “Electronic Meeting Systems to Support Group Work,” *Communications of the ACM*, vol. 34, pp. 41-61, 1991.
[38] M. Turoff, “Virtuality,” *Communications of the ACM*, vol. 40, pp. 38-43, 1997.