“全球传播论坛”文库（四）

Global Cities in e-Times: Communication, Design & Creativity

e时代的全球都市：传播、设计与创意

主　编　张国良

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一、全球化社会的
媒体景观与生态

Visible Effort: A Social Entropy Methodology for Managing Computer-Mediated Collaborative Learning

Sorin A. Matei, Robert J. Bruno, Pamela L. Morris, Anthony Faiola

Introduction

A large amount of research supports the benefits of group collaboration in terms of positive outcomes, individual satisfaction, and powerful cognitive effects(Johnson and Johnson, 1999; Slavin, 1996). The practice of computer-mediated collaboration(CMC) comes in many forms and many definitions for its meaning have been proposed. However, much research still needs to be done to understand the nature of the processes that take place during CMC. For example, despite recurring claims that online collaboration is innately egalitarian(either in terms of access or outcomes) and potentially superior due to some form of "collective intelligence" that spontaneously emerges without much coordination(Kelly, 1995; Rheingold, 2002), there is mounting evidence that online interaction follows traditional patterns of human interaction (Matei and Ball-Rokeach, 2001; Lampe, Ellison, and Steinfield, 2006).

We hold that CMC needs division of labor, coordination, and clear goals. Moreover, CMC groups that are rooted in norms or local cultures and that foster specific ethical guidelines are more likely to be productive. Conversely-and quite significantly-individual effort, inputs, and outputs are regularly observed to be *unevenly distributed* with naturally-occurring coordination and/or power hierarchies accompanying these uneven distributions.

Barabasi(2003) and Huberman(2001) have documented this uneven distribution for linkages between websites while Anderson(2006) and Shirky(2008) have done the same thing for online interactions related to e-commerce and online content consumption.

It is therefore of great importance that online collaboration be supported by new tools and be studied with appropriate methodologies that determine in what manner such uneven distribution of effort functions or how it can be modeled to facilitate maximum individual and group effectiveness. At the same time, egalitarian work paradigms can and should be employed in an informed, measured and intelligent manner. This is especially important in view of numerous claims that egalitarian collaborative systems are the preferred future organizational form (Brafman and Beckstrom, 2006), which would foster some form of "wisdom of crowds" (Tapscott and Williams 2006; Lease 2007; Powazek 2009).

Some practitioners speculate that online groups are particularly adept at solving large problems by breaking them down into smaller and roughly similarly sized tasks to be allocated to many uncoordinated participants (Tapscott and Williams, 2006). A related expectation is that the larger the group and the more equitable the social structure, the more likely the problem will be solved effectively (Brafman and Beckstrom, 2006). An example, an often invoked broadly-distributed process such as open source software development, has been labeled by Raymond(2001) as the "bazaar" process. Accordingly, he notes that the hugely successful Linux operating system is the product of "bazaar" style micro-negotiation and collaboration between unknown and equally qualified programmers who take turns in fixing each other's mistakes. Illustrating the power of distributed open source programming, he states that, "Given enough eyeballs, all bugs are shallow" (p.30).

The egalitarian assumption that surrounds online interaction can be interpreted in many ways. One could be that equality of access should not be confounded with that of outcome or consumption. This distinction could be very important if the undeniable fact that the Internet gave more people more access to educational, business, or entertainment resources than previous media, is to be reconciled with the body of observable evidence, supported by sociological theory, which suggests that collaboration online is in fact highly structured, that the Web has leaders and followers, and that equality of contributions and consumption is rarely if ever present in spontaneously emerging online groups (Kuk, 2006; Shirky, 2008). In opposition to Raymond's perspective, Kuk found a correlation between structuring, participation inequalities and the most productive processes of open source software development.

Taking a cue from this evidence, we propose a method for measuring the amount of equality and the emergence of social structure in groups that participate in CMC. The method relies on measuring the level of social "entropy" of an online environment. Social entropy, which will be discussed at length below, captures the degree of equality, evenness, and diversity of collaboration in any given system or group. The measure is visualized within the wiki environment "Visible Effort" (VE)[①] with color-coded page frames and graphs, which can be used by learning groups for self-monitoring their collaborative progress. See Figure 1.

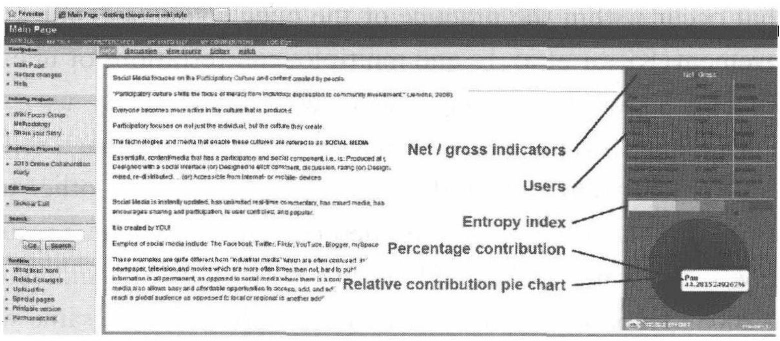

Figure 1. Screen capture of *Visual Effort* interface, with labels indicating various tool components.

The measure and visualization method proposed serve two goals. First, they are used for measuring and visualizing the degree of collaborative

① http://veffort.us.

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evenness and emergence of social structure in a collaborative online wiki environment. Second, it can be used for steering the collaborative processes to attain specific goals (Matei, Oh, and Bruno, 2006). This can be accomplished either passively or actively. It can passively provide users feedback on the processes that take place in their online space or can actively provide site administrators, project leaders or instructors the information necessary to intervene and moderate collaborative efforts. The present paper will illustrate these capabilities by describing a specific quasi-experimental teaching activity in tandem with a detailed discussion of theoretical justification, methodological underpinning, and technological capabilities of the VE approach.

CMC and Uneven Online Interaction

A significant amount of empirical evidence indicates that CMC in online environments tends to be distributed in the shape of a highly skewed curve (Anderson, 2006; Huberman, 2001; Kittur et al., 2007; Ortega, Gonzalez, and Robles, 2008). Examples include the well-known metric of 10% of Wikipedia editors contributing almost 90% of the online encyclopedia's articles (Ortega et al., 2008); similar inequities of production along the lines of 20% to 80% that occur within the practice of the open source software (OSS) and Linux movement (Kittur et al.); and multiple manifestations of uneven social distributions on Yahoo user groups, assorted emailing lists, user-generated "question & answer" forums, and so on (Kittur et al.). Although utilizing different measurement techniques and theoretical perspectives, other terms that have cropped up in recent years to describe this extreme inequality are "Zipf's Law", "Power Law", or "long tail" distributions (Anderson, 2006; Barabasi, 2003; Huberman, 2001). These terms point in the same way to the fact that online phenomena, be it amount of contributions to a user-generated site, traffic, overall attention or usage share are highly skewed (Huberman, 2001). While the figures are nominal, Nielsen (2006) proposing for the online environment a so-called "90/10/1" rule, they collectively suggest the high degree to which online interaction can be skewed.

However, this phenomenon is not only native to computer-mediated

environments. Seminal studies of small discussion groups ranging in size from a few to more than a dozen showed that top contributors dominate the conversation to the tune of 40%-50% of the time, with the next participator coming in at a percentage in the teens, and all those that follow generally registering below 10% of the total(Bales, 1950; Stephan and Mishler, 1952). This suggests that human interactions tend to follow a skewed output and input allocation curve. While part of such skewness can be tracked to power, privilege, and control issues, much of it can be put under the rubric of functional differentiation of roles and tasks (Bailey, 1990). Any task-oriented group needs to allocate roles, rewards, responsibilities, and workloads. Allocation involves a coordination mechanism, attendant communication processes, implementation schedules, and so on. These work best when redundancies are minimized and activities are distributed according to the nature of the task and to individual qualifications. These processes result in uneven distribution
of individual input and output. Thus, a significant part of group inequalities 7
can be tracked down to the functional requirements of forming human groups.

While the reality of uneven online collaboration and its impact is an undeniable fact, its ultimate theoretical explanation is still insufficiently understood. To some online activists and media observers, who for the past two decades have promoted the idea of cyberspace as a liberating and equalizing force(Barlow, 1994; Benkler, 2007; Hiltz and Turroff, 1978; Tapscott and Williams, 2006; Raymond, 2001), these findings might appear as an exception or declining phenomenon. Yet, this opinion might ignore an important argument. As groups increase in size, they meet the hard barriers of mounting transaction costs. When narrowly defined, such costs are the financial expenditures associated with social and economic exchanges. When broadly understood, transaction costs are the energy, time, or financial spent on maintaining a group's coordination and communication mechanisms (Coase, 1937; Surowiecki, 2004). In the absence of hierarchies and division of labor, group members need to constantly survey all the other members and communicate with them to keep the project going. This takes more and more attention and resources, which as the group increases in size can undermine its ability to subsist as a whole. The typical solution to this problem is to create specialized roles and coordination mechanisms, which allow some of the members to work on the intended group goal, while other members manage the collaboration process. It is also only fair to note that highly hierarchical and strictly compartmentalized groups, with tightly defined divisions of labor, can run into problems of their own. The most prominent is that of inefficient utilization of resources, poor allocation of effort, and inability to fully capture and redistribute local or tacit knowledge throughout the organization(Coase, 1937).

The dilemmas of human collaboration were neatly captured in the seminal work "Wisdom of Crowds" (Surowiecki, 2004). Although sometimes understood as an argument for flat organizations and egalitarian collaboration, the book makes a more complex point. It highlights the fact that task-oriented social groups work optimally when combined with a high degree of autonomous decision supported by flexible methods of aggregating and communicating information about group processes. Groups are, according to him, more likely to come to right solutions when sufficient diversity of opinion, expertise, and interest is combined with social structures and communication tools that can aggregate these opinions and experiences and make them visible to the group in an effective way. Extending Surowiecki's phrase, we propose that for groups to be wise, they need division a labor, role allocations, and the communication tools and channels that allow them to become aware of their own inner working. Furthermore, self-awareness can be enhanced if information refers not only to the task and its completion rate, but also to the manner in which its outcome is produced. Given the uneven and social structured nature of human tasks already discussed, it is especially important that information aggregation systems communicate in an effective manner how effort has been allocated, who has done what and to what effect. While this can be accomplished in many ways, the ideal situation would be one where such information reflects both global and individual facets of collaboration. In what follows we will present a methodological approach and online tool for monitoring and fostering group collaboration, especially in a learning environment. The tool provides information about the level of collaborative evenness and group structure through charts and colors that reflect group entropy levels. In addition, the tool is meant to facilitate our understanding of how uneven collaboration influences group effectiveness especially in a learning environment.

Measuring Collaborative Unevenness

Shannon's Entropy Theory

In previous work (Matei et al., 2006) we have proposed Shannon's Theory of Communication (Shannon and Weaver, 1949) as an approach and its companion measure, social entropy, as a possible measure for understanding collaboration within online and/or technological systems, especially wikis. As is well known, Shannon used the social entropy index to capture the degree to which a communication system contains information (Shannon and Weaver, 1949). To accomplish this, Shannon employed a well-known physics measure, namely entropy, which is connected to the second law of thermodynamics, that states that all physical systems have a tendency to devolve to the point where the level of energy is zero and all their elements are equally likely to be in a random state. Shannon took the entropy measure from the physical to the communicative and as we will show below, to the social realm. His novel proposition was that communication can be conceived in terms similar to those of a physical system. In nature, when all elements of a system (e.g., atoms) occur randomly, their prevalence is approximately equal. The system is in a state of chaos and entropy is at a maximum. When physical particles get organized in more and more complex compounds, which privilege some elements at the expense of others, entropy decreases.

Communication can be seen as a system as well. Symbols, similar to atoms in the physical world, are the basic units. A communication system will probably contain no information and its entropy will be at a maximum, when symbols are equally likely to occur. In other words, when the order of the symbols is decided by chance alone there is no information (Shannon and

Weaver, 1949). On the other hand, information-laden communication will utilize specific units of meaning more often than others, and entropy will decrease as symbols, just like physical particles, occur in a biased manner (Seife, 2007). Thus, if applying the entropy formula to a communicative system, the less organized it is, the higher the entropy and the less likely to contain information. The opposite is also true—the more organized the system, the higher the amount of information, and the lower the entropy.

Social Entropy Theory

Shannon's theory can be extended further, from communicative to social interaction. If we consider communication broadly, as the main mechanism by which social interaction takes place, all human affairs can be understood through the exchange processes that make them possible. Social interaction can be seen as an extended process of communication reliant upon a system of symbols and can be studied through the lens proposed by Shannon. Social systems whose members interact with each other in a nearly random manner, quasi egalitarian, are more likely to lack a definite structure. Social systems that form a specific structure of interaction, where symbols are exchanged according to specific rules and patterns possess a more definite, structured form. Moreover, while in the first situation the exchanges will be completely even in terms of output/input ratios (everyone is equally likely to send symbols to everyone else), in the second case there will be a definite bias in terms of who will send information to whom.

From a mathematical or statistical perspective, social entropy measures to what degree specific system units (individuals) are more likely to contribute to or in the workings of the system than what chance alone would predict. The social entropy of a group is maximized when a group member is just as likely to communicate, share the effort or contribute an output unit as any other member. In statistical terms, for each of them, contribution would not be greater than what chance alone would predict. It would be purely random. On the other hand, as members take upon themselves or are assigned specific tasks and communicate in a patterned way by interacting in a preferential manner with other members, frequency and amount of output or contribution become non-random. Chance alone cannot predict these outcomes. Entropy, when measured as likelihood of individuals to contribute randomly, starts to decrease. When non-random behavior emerges, however, we have more than simple unevenness and deviation from what chance alone would dictate. Patterned interaction goes hand in hand with roles, rules and division of labor or functional differentiation. The group has become, in fact, structured. More concisely, a social group is more structured when its members are organized in a specific chain of communication and coordination, where some interact more than others, and less structured when members interact randomly (thus, theoretically, equally) to each other. Calculating the entropy of each social situation reveals in fact how structured the group is. Structure is inversely proportional to entropy.

Entropy: A Higher Level Structural Indicator

As previously mentioned, groups that are dominated by some of its members are also more likely to have a given structure. This structural characteristic can be captured in a direct way by social entropy: top heavy groups have lower, while egalitarian groups have higher entropy levels. In this we take a cue from Shannon's original intent in proposing social entropy as a measure for how "informed" (organized) a social (communicative) reality is.

In extending Shannon's theory from information to other realms of inquiry, we continue a line of work with a distinguished past. For example, social and communication scientists, such as Hitlz and Turoff (1978), Schramm (1955) or Bailey (1990) have applied entropy theory and its attendant methodologies to specific social scientific problems, such as small group structuring, system theory, media landscape organization, diversity of media production, and so on. Economists, environmental scientists, or human geographers have also used entropy to characterize the social structure and diversity of industries, occupations, species, or populations (Bailey, 1990; Matei et al., 2006).

In our own work we have analyzed the emergence of social structures on

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