Awareness and Virtual Cooperative Interaction in the Learning Web

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ABSTRACT The article investigates *awareness* issues involved in the learning web. It presents a conceptual model for *virtual cooperative interaction* and examines how one would ensure the continual participation and contribution by information providers to the web. For example, a virtual art gallery on the web has an *intensional expectation* of its potential audience: guest artists often contribute in order to gain recognition from peers; and its webmaster can gain satisfactions via receiving popular site awards (e.g., "the best website for cubism"). The example involves social psychological processes which instigate and maintain *virtual cooperation*. These processes can be analyzed by the motivational and reinforcement aspects of the conceptual model. These phenomena are common in existing activities such as those of scientific research communities and those of emerging learning communities on the Internet.

1. INTRODUCTION

The 1990s have seen the emergence of large scale collaborative activities on the Internet using email, list servers, news groups and the World Wide Web. There have also been developments of systems using some of these technologies to support smaller closely-coupled collaborative learning groups. In terms of the standard time/space taxonomy for CSCW (computer-supported cooperative work), these uses of the Internet are generally virtual in space and range from highly synchronous to highly asynchronous interactions. However, many of the major applications of the Internet raise new issues that are not adequately addressed by existing models and taxonomies of CSCW. Small groups of individuals working together generally have well-defined roles and mutual awareness of roles, tasks and activities. However on a list server, a discussion may be initiated with only a vague concept of other potential participants but with strong expectations that a collaborative activity will result. On the World Wide Web material may be published without only a vague conception of potential users yet that material may play an essential role in a collaborative active in some community, possibility not involving the originator, and perhaps a community of which the originator is not part.

The web was originally conceived and developed at CERN for the purpose of assisting and facilitating collaborative interactions among high energy physicists, working at various institutions in different countries, to conduct joint research projects. Since 1993, it has diffused at a phenomenal rate and gradually has subsumed various popular Internet services such as: USENET news group, electronic mail, etc. The original charter of the web is summarized in the following quote: *The World Wide Web was developed to be* ***a pool of human knowledge****, which would allow collaborators in remote sites to share their ideas and all aspects of a common project* [Berners94].

The notion of the **learning web** was presented at EdMedia '95 as: *a systemic approach to the modeling and support of knowledge processes in a learning society* [Norrie95]. This paper develops a model of virtual cooperative interaction and the support of awareness in the learning web. In carrying out cooperative learning, learners use a variety of tools. The proliferation of **computer mediated environments** (CMEs, e.g., conferencing systems, shared media space) allows learners to utilize the new resources for their cooperative interactions. CSCW or groupware systems are often classified as supporting either synchronous or asynchronous cooperative interactions; but this simple distinction fails to capture the complexity of large scale collaborative work. Typical groupware supports cooperative interactions ranging from small closely coupled team numbering 2-5 people (e.g., co-authoring systems [Neuwirth94]) to large group of participants numbering 50-100 (e.g., electronic meeting systems [Dennis90]). However there is now an emergence of *large scale groupware* on the Internet and World Wide Web, with participants numbering in hundreds or thousands.

2. THE LEARNING WEB AS SOCIOWARE

The diffuse collaborative communities that have formed on the Internet suggest the need to reconsider existing notions of CSCW. Large scale groupware differs not only in the quantity, but also in the quality of cooperative interaction. The fundamental nature of interaction on the web can be characterized as **virtual cooperative interaction**. The word "virtual" has two senses here: first, it denotes the notion of *virtual space*, i.e., the cooperative interaction occurs in a non-physical space which allows participants to be situated in geographically separate locations; second, it denotes that the *intention* to engage in cooperative interaction itself may not necessary pre-exist or be conscious. Traditional notions of groupware focus on the first sense (tele-presence in virtual space), but there is a need to extend the notion of cooperative interaction to encompass the latter sense of virtual cooperative interaction also.

Frequently, information resource contribution and exchange on the web involve cooperative interaction without pre-planned coordination. In fact, participants on the web may have no intention to cooperate in the first place. Quite often, a resource provider and a resource user are unaware of each other's existence until their first interaction. Nevertheless, the interactive process between them is still loosely cooperative in nature. It is an unusual form of cooperation where a resource provider might never know the identity of her resource users, nevertheless still continues to contribute anyway. It differs from the traditional team-oriented cooperation where group tasks, goals, and purposes are usually well-defined. What does she gain in return in such a seemingly one-way cooperative interaction? Is it simply an expression of altruism? What are some possible motivations for her to contribute to the web? In general, how would one ensure the continual contribution of an information provider? These questions can be answered more clearly in the context of *socioware*.

The present paper defines **socioware** as: *computer-mediated environments for supporting community-wide processes which expedite virtual cooperative interactions.* Information inquiry and response, dissemination of ideas, and social networking are examples of functionality of the learning web [Norrie95]. In essence, the goal of socioware is to facilitate emergent pro-social behaviors for self-organized, virtual collaborative communities. This paper models the Internet as a whole (the web/net) as large scale socioware supporting cooperative interactions which differ qualitatively from goal directed, highly coordinated team-oriented collaborations supported by conventional groupware.

3. CONCEPTUAL MODEL OF THE LEARNING WEB

This section describes a detailed learning web model that encompasses collaborative activities supported by traditional groupware and by emergent socioware. The model analyzes the following five basic elements for the learning web in terms of virtual cooperative interaction:

1. *discourse patterns*
2. *time-dimension of virtual interactions*
3. *awareness hierarchy*
4. *motivations for cooperative behaviors*
5. *emergence and maintenance of virtual cooperative interaction*

Together they present three aspects (what, why, and how) of the conceptual model: (i) the descriptive aspect comprised of the first three elements which characterize and classify virtual cooperative interactions; (ii) the prescriptive aspect that provide motivational reasons for individuals to participate in virtual cooperative interactions; and (iii) the operational aspect of how virtual cooperative interactions initiate and function.

3.1 Discourse in Virtual Cooperative Interaction

Communication is an essential element of cooperative interaction. Generally speaking, there are two types of communications on the Internet, namely: *discourse* and *publication*. This subsection proposes a temporal punctuated-discourse model of virtual cooperative interaction which models both modes in an integrated way.

3.1.1 A Punctuated Discourse Model

A conventional taxonomy of Internet might describe its services in terms of their utility, but it does not provide an integrative model of the way in which they support communities. Such a model can be developed by noting that what distinguishes discourse from publication is that in discourse it is expected that the recipient responds to the originator, whereas publication is generally a one-way communication. However, on list servers some material is published in that the originator expects no specific response, and material published in electronic journals or ar-

chives often evokes a response. The following diagrams show the different characteristics of the main Internet services in terms of these issues.

Figure 1 shows email discourse as a cycle of origination and response between a pair of participants communicating through a computer-mediated channel. Figure 2 extends Figure 1 to show list server discourse as a cycle of origination and response between participants that is shared with a community through a computer-mediated channel. The community involvement leads to more complex discourse patterns in that: the originator may not direct the message to a particular recipient; there may be multiple responses to a message; and the response from the recipient may itself trigger responses from others who did not originate the discourse. For a particular discourse sequence this leads to a natural division of the community into *active participants who respond* and *passive participants* who do not.

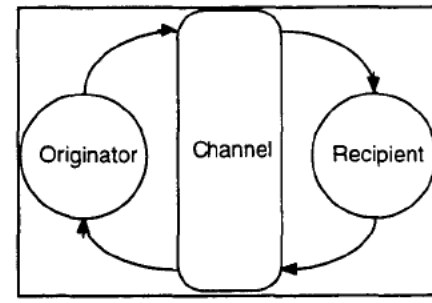

Figure 1 Email discourse

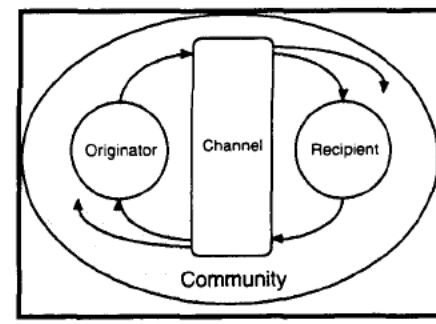

Figure 2 List server Discourse

Figure 3 modifies Figure 2 to show web publication as an activity in which the channel is buffered to act as a store also. The material published is available to a community and the originator is unlikely to target it on a particular recipient. Recipients are not expected to respond direct to the originator, but responses may occur through email, list servers or through the publication of material linked to the original. Because the published material is not automatically distributed to a list, recipients have to actively search for and discover the material. The common structure adopted for the diagrams is intended to draw attention to the commonalties between the services. List server discourse is usually archived and often converted to Hypermedia on the web. Web publications do trigger responses through other services or through links on the web. A search on the web may not discover a specific item but rather a related item on a news group, list or by an author, and result in an request for information to the news group, list or author. Individuals and communities use many of the available services in an integrated way to support their learning processes. Figure 4 subsumes Figure 1 through Figure 3 to provide an integrated model of the learning web on the Internet that captures all the issues discussed. It introduces two major dimensions of analysis: the *times* for each step in a discourse cycle; and the *awareness* by originators of recipients and vice versa.

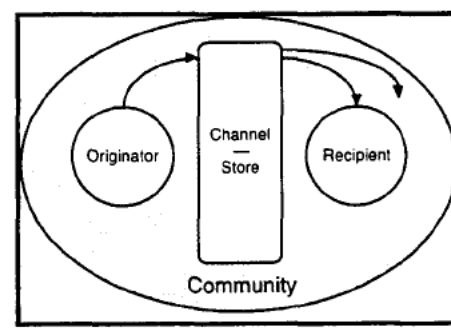

Figure 3 World Wide Web Publication

3.1.2 Time-Cycle of Punctuated Discourse

The four times shown in Figure 4 are:

- t1: the origination time— the time from a concept to its expression and availability
- t2: the discovery time— the time from availability to receipt
- t3: the response time— the time from receipt to expression and availability of a response
- t4: the response discovery time— the time from response availability to receipt

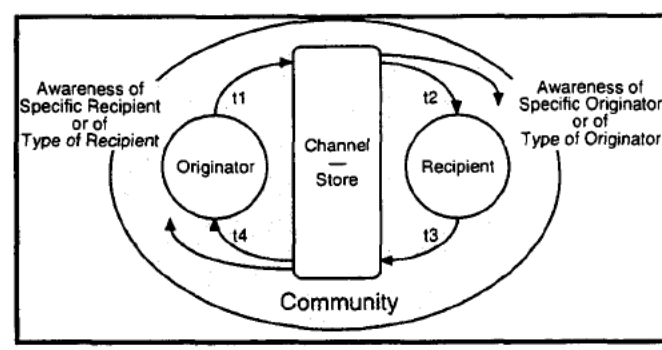

Figure 4 Punctuated Discourse

Note that individual's cognitive processing times and channel delays have been lumped. A study focusing on the impact of communication delays would want to consider them separately, otherwise there is no significant distinction. A general principle might be that communication delays should not be greater than individual's cognitive processing times. Note also that the diagram is to a large extent symmetrical— the recipient becomes an originator when responding.

An important overall parameter is the round-trip discourse time, t1+t2+t3+t4. The **time-cycle** of virtual cooperative interaction is defined by averaging the round-trips of discourse times. If this is small, a few seconds or less, we talk in terms of synchronous communication. If it is large, a few hours or more, we talk in terms of asynchronous communication. If it is infinite, so that there is no response, we talk in terms of publication. However, this analysis shows that there is a continuous spectrum from synchronous through asynchronous to publication. The discovery times, t2 and t4, are very significant to publication-mode discourse, and attempts to reduce them have lead to a wide range of *awareness-support tools* that aid potential recipients to discover relevant material and originators to make material easier to discover [Gaines96, Chen96].

3.2 The Time Dimension in The Learning Web

When two or more individuals participate in the learning web, they often take on dual roles of originator and recipient in punctuated discourse. Gradually they become locked into *social entrainment processes* [McGrath90]. Computer-mediated environments, such as news groups and shared drawing systems, provide specific external signals which set the pace of virtual cooperative interactions for participants. For example, the average *time-cycle* for posting to a news group and receiving a feedback is about one to few days. Whereas the partial time-cycle (t1+t2) for moving a mouse cursor in a real-time shared drawing system is around one to ten seconds. *External entrainment* [McGrath90] occurs when the *actual* time-cycle of a virtual interaction fall into the range of the *expected* time-cycle anticipated by individual participants. When there is a wide discrepancy between the expected and the actual time-cycle of interaction, participants often feel frustrated and decrease their desire to interact. For example, if cursor movements in a shared drawing system begin to take more than a few seconds to complete, the participants will tend to stop their interaction.

Continuation of virtual cooperative interaction can also break down when *mutual* and *external* entrainment processes are not synchronized with one another [McGrath90]. When co-reviewing a book, the natural time-cycle for mutual entrainment is in days and weeks, since it often take that a mount of time to read a book and absorb the material properly. It is unlikely that co-reviewers will want to use IRC (Internet Relay Chat) to disseminate and exchange their reviews. Such a fast time-cycle of interaction is not well suited for activities involving deep, reflective cognitive processes.

The time-cycle in the learning web often varies according to cognitive processes involved in any given moment of an activity. For example, during a collaborative writing session [Neuwirth94]: when co-authors' focus is on correcting sentences or paragraphs, the time-cycle involved is usually around few minutes; and when they focus on reviewing chapters, the time-cycle involved shifts to hours. Therefore co-authoring systems are classified in the range of time-cycles from second to day, in addition to be extensional oriented. The time dimension diagram of virtual cooperative interactions allows us to visualize CMEs in terms of an *interaction area* they encompass as shown in Figure 5.

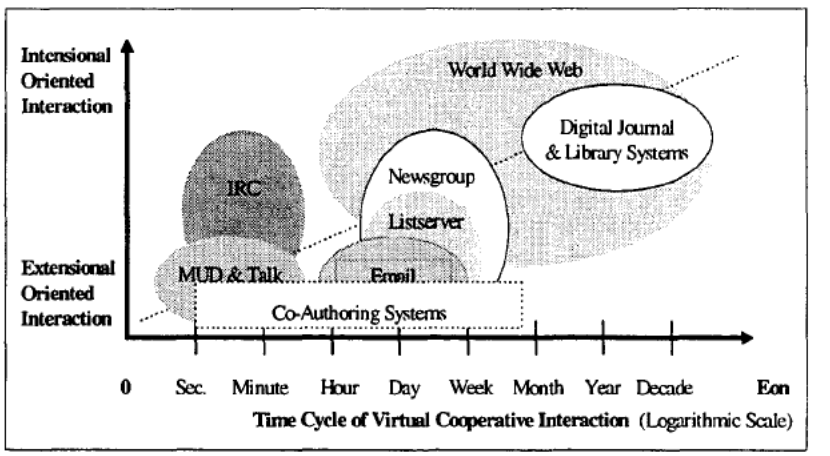

Figure 5 Time Dimension of Virtual Cooperative Interaction

Many groupware systems have been designed to support collaborative teams in which interactions are between known group members. In contrast, interactions in USENET news groups involve both extensional and intensional awareness of targeted audience. For example, one can respond to a question from a specific individual (an extensional oriented interaction) but do so publicly with the intention to address others who may have a similar question in mind (intensional oriented interaction). The relationship between the time-cycle and the relative strength of *extensional/intensional awareness* in the learning web can be illustrated in a time-dimension diagram (Figure 5). If the time-cycle is relative short, say in few seconds or minutes, we have an interaction that can be characterized as synchronous (real-time). If it is longer, we have interaction that is often described as asynchronous (delay-time).

	Team	Special-Interest Community	Community at Large
Resource Provider	Extensional awareness of actual users.	Intensional awareness of types of users.	No awareness of users, or only weak intensional awareness of types of users.
Resource User	Extensional awareness of actual resources and providers.	Extensional awareness of actual resources and providers, or intensional awareness of types of resources and providers.	No awareness of resources or providers, or only weak intensional awareness of types of resources and providers.

Figure 6 Communities Distinguished by Awareness

The key notion here is that the types of virtual cooperative interactions are differentiated on a temporal continuum rather than by discrete categories.

3.3 Awareness Hierarchy of Virtual Cooperative Interactions

At least three types of virtual cooperative community need to be distinguished. A **team** can be treated from a *collective stance* [Gaines94] as a single psychological individual that behaves as a compound role generated by the distributed activities of roles in a number of people. Each resource provider in a team has an *extensional awareness* of their actual resource users, and each resource user has an extensional awareness of the resource and who will provide it. In the tightly-coupled team, each person is usually aware of who will provide a particular resource and often of when they will provide it. In logical terms, this can be termed **extensional awareness** because the specific resource and provider are known, as contrasted to **intensional awareness** in which only the characteristics of suitable resources or providers are known. Both types of awareness are important in the awareness hierarchy of virtual cooperative interactions [Gaines96].

In a **special interest community** resource providers usually do not have such extensional awareness of the resource users, and, if they do, can be regarded as forming teams operating within the community. Instead, resource providers usually have an *intensional awareness* of the resource users in terms of their characteristics as types of user within the community. Resource users in a special interest community may have an extensional awareness of particular resources or resource providers, or an intensional awareness of the types of resource provider likely to provide the resources they require. This asymmetry between providers and users characterizes a special interest community and also leads to differentiation of the community in terms of core members of whom many users are extensionally aware, and sub-communities specializing in particular forms of resource [Gaines96].

In the **community of users at large**, there is little awareness of particular resources or providers and only a general awareness of the rich set of resources is available. Awareness of the characteristics of resources and providers is vague, corresponding to *weak intensional awareness*. These distinctions lead to human factors consequences in terms of the appropriate awareness mechanisms that need to be established for the learning web to function. In a team, resources may be identified precisely by location and name. In a special-interest community, resources may be identified by an intensional indexing scheme that classifies them in terms of the distinctions made by that community. In the community of users at large, resources may be identified both by indexing their content type using a wide variety of taxonomies and by indexing their actual content. These distinctions are summarized in Figure 6.

3.4 Motivations for Participation in the Learning Web

When many individuals participate in a multitude of punctuated discourses (Figure 4), a chain reaction occurs. The accumulative effect generated by this chain of inquiry-response-reaction-response-reaction (and so on) is an evolving topical thread that can become a part of *shared knowledge* among community members. Through automatic archival services such as Hypermail or some individual efforts such as FAQs (Frequently Asked Questioned) and webpages, the shared knowledge persists and grows. An interesting question is: why should individuals contribute to this pro-social process?

Generally, interpersonal behavior can be characterized as a *social exchange* between people, and these social exchanges typically involved both rewards and costs to participants. On balance, an individual will perform those actions which produce the greatest rewards at the least cost [Shaver87]. Therefore according to this cost-benefit calculus, a perceived potential for rewards must exist for individuals to participate and contribute in a cooperative relationship. In contrast with classical social exchange theories [Cook87] (e.g., Kelly and Thibaut's interactional

matrix model [Kelly78]) which emphasize dyadic interactions between individuals, **collective social exchange theory** focuses on interactions between individuals and their community. Conceptually, the Internet community is viewed from a *collective stance* [Gaines94] as an entity to 'whom' individual participants exchange information resource with. This collective entity offers participants a valuable informational service (namely, as *a pool of human knowledge* [Berners94]) in exchange for their contributions.

The *norm of reciprocity* is fundamental to social exchange and leads to contributing behavior. The reciprocity norm creates an obligation for repayment that must be satisfied if the interaction is to continue [Shaver87]. However, the way reciprocity operates in collective social exchange is more subtle than in conventional social exchange between individuals. Why should one reciprocate (through contribution) in a situation where social responsibility is relatively *diffused* among community members? One motivation for contributing to the net is for individual to gain positive *self-image* [Jones82]. In this case, an individual has internalized the norm of reciprocity and acts according to the principle of **equity theory**: that is, a person will seek to maintain his ratio of rewards to costs as the same as that of relevant comparison persons [Walster78]. A sense of *guilt* would occur if the individual perceives he has not contributed enough to the community. Hence, he would want to reciprocate fairly.

Another more subtle motivation is that of contribution as an investment in **social power**, that is, the *capacity* of a person or group to affect the behavior of another person or group [Schopler65]. Contributions made by an individual may not only help others but may also help her to gain name recognition from peers. The more one contributes publicly and receives recognition for one's contributions, the more one gains the capacity of power to influence others or the community as a whole. The added weight in recognizing who is first to contribute relevant information also motivates individuals to volunteer information resource more readily. The competition for priority in contribution has been well documented in Merton's studies on the reward system in scientific discovery [Merton73].

The motivational dimension illustrates the importance of *feedback loops* [Losada90] in the reinforcement of virtual cooperative interaction. It provides a coherent explanation for the apparent altruistic behavior of information providers on the web.

3.5 Reinforcement of Virtual Cooperative Interactions

Possible motivations for providing information resource on the web are gaining positive self-image and name recognition. But how does a pro-social behavior initiate and continue? The concern here is with the relationship between the *effect* of an individual's behavior in a *virtual cooperative community* and its impact on the individual's later behavior. This is the basis to **operant conditioning**, the learning process by which behavior is modified by it the consequences of previous similar behavior [Ritzer92]. An individual emits some behavior. The community in which the behavior occurs in tern "acts" back in various ways. The reaction—positive, negative, or neutral— affects the individual's later behavior.

Social learning theory suggests that novel social behavior is first learned through imitation of actions taken by others who act as (social) models [Bandura63]. The reinforcement received by a model serves as information to the person about which behaviors are acceptable and appropriate for the circumstances. Once a novel action has been acquired through imitation, its probability of continuation is depended on the reinforcement it receives. *Vicarious reinforcement*, as well as direct reward or punishment, can play a part in social learning [Shaver87].

On the web, an individual's first successful encounter with a homepage full of relevant information resource provides a positive role model for imitation. Her subsequent positive net-surfing experience will further increase her exposure to other positive models. Once an individual internalizes the web culture which encourages construction of personal homepage (which coincidentally also provides virtual persona for self-image), she will come to view that contribution to the web as a pro-social behavior and act accordingly. The dynamic of *social exchange* then comes into play here, if the costs of putting up information resources (e.g., research papers, hyperlinks to relevant webpages) are relatively low to her (e.g., she has necessary skills and resources), she would contribute to the web. In addition, an original intention to contribute to the web community does not need to exist, she may use her homepage to organize her knowledge resource and contribute to the web community as an after thought (or as a by-product). In this situation, the extensional audience is herself together with a vague sense of intensional awareness of other potential resource users. This form of contribution in punctuated discourse is depicted in Figure 3.

How does reinforcement come into the picture? Frequently, one would encounter some homepages that had been constructed months or years ago without any revisions or new contributions. Their authors have neglected them and ceased to contribute. Once a novel behavior has been acquired, it needs to have *intermittent, positive reinforcements* to sustain the behavior [Bandura63]. In order for reinforcement to take place, there must exist a feedback loop like the one depicted in Figure 4. The round-trip cycle (t1+t2+t3+t4) of virtual cooperative interaction provides an individual the necessary awareness of the *effectiveness of investment in social power* which is crucial to reinforcing the behavior and leading to similar future actions.

An observable measurement of the effectiveness of social power on the web is the relative popularity of a website. The popularity of a homepage can be inferred from recognition earned by its visitor frequency counter, commentaries in its public guest-book, awards given by reviewers of popular websites, and the number of other webpages linked to the page, etc. These gauges of popularity (which measure the relative power for social influence) provide direct reinforcements (can be either positive or negative) to an information provider. They also offer indirect, vicarious reinforcements to other information providers by providing social models for comparisons.

4. SUMMARY AND CONCLUSION

The support of virtual collaborative interaction on the Internet has developed pragmatically without deep conceptual models. Awareness-support tools such as Yahoo and Lycos have been developed because of a perceived need to ameliorate information overload through better indexing tools. However, the indices generated by these tools also contribute to the social exchange mechanisms that motivate participation in Internet communities, and the design of such tools has to recognize their multiple roles.

	Groupware	**Socioware**
Awareness	strong mutual extensional	weak mutual intensional
Time-Cycle of Interaction	short to medium (seconds to days)	medium to long (days to years)
Motivation for Cooperation	individual social exchange	collective social exchange
Power Relations	well-defined roles as part of team definition	emergent roles from investment in social power capacity

Figure 7 Comparisons between Groupware and Socioware

The early development of the conceptual model described in this paper led to the authors' realization that *chronological awareness* was not well-supported by existing web tools [Chen96]. CHRONO[1] is a tool resulting from this analysis. We noted that one dimension of awareness management is keeping track of a site where relevant information has been available in the past. CHRONO generates a "what's new" page for a site automatically by indexing the site in reverse chronological order so that a visitor may readily note changes that have occurred since his or her last visit. *WebWatch* [Specter95], *Katipo* [Newberry95], and *URL-Minder* [NetMind95] are other chronological awareness tools that track changes in specified documents. The key question to ask in developing new awareness support tools is "what is the starting point for the person seeking information? i.e., the existing information that is the basis for the search" A support tool is then one that takes that existing information and uses it to present further information that is likely to be relevant. Such information may include relevant concepts, text, existing documents, people, sites, list servers, news groups, and so on.

The conceptual model presented in the article implies that for successful maintenance of continual virtual cooperative interactions in the learning web, the following criteria must exist:

- establishment of resource awareness for initial encounter
- establishment of mutual awareness as a feedback loop for continual virtual cooperative interactions
- compatibility between the expected and the actual time-cycles of virtual cooperative interactions
- properly situated expectation of fairness in terms of collective social exchange
- accumulation of positive feedback for reinforcements in virtual cooperative interactions

The current model can also be used to categorize computer-mediated environments roughly into groupware and socioware (Figure 7). It also identifies the types of systems that are needed to expedite collaborative activities. It

[1] For more information on CHRONO and others awareness tools: see: http://ksi.cpsc.ucalgary.ca:8008/cgi-bin/release?cmt7

focuses on participants' motivations and power relationship which determine their social roles, goals, expectations in the learning web.

The article contributes to CSCW research by drawing attention to their added significance in socioware like the web where social and organizational structures are fluid and less well-defined. The conceptual model for virtual cooperative interactions in the learning web expands the scope of groupware research. It provides a framework encompassing all forms of CSCW from teams through organizational workgroups to diffused, evolving communities. Modeling and supporting virtual cooperative interactions on the Internet are important new challenges for distributed learning research.

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