Social cybernetic strategies for asynchronous learning

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Abstract

In over 4 decades of experience with computer-supported learning (CSL), applications have progressed from rote training with primitive computer work stations, to today's web-based applications for support of online learning communities (OLCs). It is assumed here that the growing focus of CSL applications on OLCs to support collaborative group learning has an inexorable momentum that parallels the trend in education generally. This report therefore advocates social cybernetic strategies to achieve effective collaborative learning during student interaction with OLC interfaces. Social cybernetic theory assumes that social interaction among individuals in a social group is a closed-loop (cybernetic) process, in which each participant behaviourally tracks and controls sensory feedback generated by movements of other partners in the group. The theory recognizes many different modes of social tracking, among them series-linked, parallel-linked, imitative, supervisory, mediated, individual-group, intra-group, and inter-group social tracking, representing different human factors designs of social interaction. Relative to the physical classroom, these modes of social tracking are either severely degraded or nonexistent in the CSL classroom. That is, typical CSL (including OLC) environments replace social tracking with informational tracking to support student learning. Introduced here are strategies for strengthening the social cybernetic designs of OLC environments in order to enhance the learning effectiveness of OLCs.

Keywords: computer supported learning, online learning communities, social cybernetics, asynchronous learning

1. Introduction and background

In over 4 decades of experience with computer-supported learning (CSL), applications have progressed from rote training with primitive computer work stations [1, Chap. 10], to today's web-based applications for support of online learning communities (OLCs) [2]. Common themes throughout this period are: (1) a persistent disregard on the part of the education community of ergonomic/human factors (E/HF) issues associated with learning generally, and CSL interface design particularly; (2) a prevailing infatuation by this community with CSL technology, rather than with how the design of this technology might influence student performance; and (3) disproportionate CSL attention to technology R&D [3], as opposed to research on student learning with CSL systems [1].

It is assumed here that the growing focus of CSL applications on OLCs to support collaborative group learning has an inexorable momentum [2,4] that parallels the trend in education generally [5]. This report introduces and delineates social cybernetic strategies to achieve effective collaborative learning during student interaction with OLC interfaces.

Social cybernetic theory assumes that social interaction among two or more individuals in a social group is a closed-loop (cybernetic) process, in which each participant behaviourally tracks and controls sensory feedback generated by movements of other partners in the group. In engaging in this social tracking process, a given participant generates (through movement) her/his own sensory feedback that is, in turn, tracked and controlled by other group participants. If this reciprocal exchange and control of sensory feedback between participants during social group interaction occurs in a mutually compliant manner, a tight social tracking yoke is established among group participants to mediate effective integration of social behaviour.

This theory also recognizes many different modes of social tracking, among them series-linked, parallel-linked, imitative, supervisory, mediated, individual-group, intra-group, and inter-group social tracking. These modes represent different human factors designs of social interaction.

In the physical classroom (continuing a tradition dating historically at least back to Socrates), featuring face-to-face (FTF) interaction among student and instructor participants, all of these modes of social tracking are employed to promote learning. With every mode, social tracking behaviour is mediated and integrated by mutual exchange and control of movements generated by different group participants. The persistence across some 2.5 millennia of the social tracking design of the traditional classroom testifies to its record of success in supporting learning.

Arguably, web-based CSL and OLCs represent the first true revolution in the design of learning environments across this entire period. The essence of this revolution is that, because of the typically asynchronous nature of student-student and student-teacher interaction in the virtual relative to the FTF classroom, the modes of social tracking cited above are either severely degraded or nonexistent. That is, OLC environments replace social tracking with informational tracking (based on visual and auditory feedback) to support student learning. Two obvious questions, therefore, are whether: (1) OLC environments can effectively support learning despite the lack of traditional modes of social tracking designs; and (2) surrogate or simulated modes of social tracking can be implemented with OLC environments to augment their learning effectiveness.

To address these questions, sections below: (1) summarize concepts and evidence pertaining to social cybernetics and to a cybernetic understanding of learning; (2) explore the implications of these findings for addressing the question of OLC learning performance; and (3) outline interface design strategies to promote OLC performance. Other publications by the author have discussed E/HF and social cybernetic issues of learning generally [6], of online learning communities particularly [7,8], and of augmented cognition [9,10]. This report applies concepts and evidence contained in these other reports to learning challenges posed by OLCs.

2. Social cybernetics

The basic idea of a 'learning community' is that of a group with a common dedication to a culture of learning in which everyone is involved in a collective effort of understanding [11]. In an OLC, interaction among members of the community occurs not in physical space (the traditional classroom) but in virtual space, through mediation of an intelligent 'agent' (computer software) responsible for facilitating such interaction [3].

The scientific approach advocated here to the analysis of interactive systems of this sort, involving multiple human-human and human-computer relationships, is grounded in social cybernetics. Social cybernetics is founded on the broader field of behavioral cybernetics, which assumes that human behavior is controlled as a closed-loop or cybernetic process [1,13,14]. The cybernetic nature of behavior becomes obvious during social interaction between two or more individuals. This is because each individual in a social context must control the sensory feedback generated not only by his/her own behavioral movements and functioning, but also the sensory feedback created by interacting with one or more social participants. The study of interpersonal and group reciprocal sensory feedback and sensory feedback control relationships represents the focus of social cybernetics, directed towards delineating the closed-loop behavioral-physiological manifestations and properties of social interaction [13-18]. Social cybernetic theory extends to team contexts a feedback theory of movement integration, and thereby assumes that team activity, like all other biological activities, is feedback regulated [19].

The term social tracking describes the feedback-controlled process by which an individual follows or tracks a social target. Social interaction is conceived as a dynamic linking of the motorsensory behavior of two or more people in a social tracking relationship. In cybernetic terms, the behavioral activities of one person in a social context affect behavioral-physiological changes in others, whose behaviors in turn feedback influence the ongoing behavior and physiology of the first. These effects arise as a consequence of control by each participant of sensory feedback generated by the other social partners.

Social tracking typically requires each participant to control multiple motor, sensory and cognitive modalities (vision, speech, writing, etc.) and transformations (displacements, delays, etc.) of sensory feedback. The social partners thus become dynamically yoked or interlocked behaviorally and physiologically, as a result of mutual body movement tracking and control of each other's sensory feedback. Through such interlocks, the participants in a social group begin to operate as an integrated system, with definite systems feedback parameters and feedback control characteristics.

In particular, as noted above, social cybernetic systems can exhibit many different types of social tracking modes, such as series-linked, parallel-linked, imitative, supervisory, mediated, individual-group, intra-group, and inter-group social tracking. These different modes, illustrated in Figure 1, are expressed in a variety of different social interactive contexts (interpersonal, group and/or institutional social systems). By definition, mutual control in social interaction to some extent compromises self regulation by the individual, but there are also potential gains in behavioral control capabilities, such as collaborative learning, that could surpass the regulatory abilities of individual participants, thus motivating social behavior.

In summary, social cybernetic theory as outlined above rests upon three basic assumptions: (1) the theory is applicable to conceptual and experimental analysis of all modes and dimensions of human social behavior and interaction; (2) both individual and social behavior are differentially specialized in relation to the organizational and environmental design features in which social interaction occurs; and (3) social human factors dominate all aspects of the human condition, dictating not only the course and level of human development, but specialization of the processes of learning, performance, schooling, aging, organizational design and management, work, and all aspects of machine-related behavior. From this perspective, social cybernetic concepts of interpersonal and group behavior create a new comprehensive framework for interpreting human social interaction with machines and technology, including particularly OLCs.

3. Cybernetics of learning

Advocates of OLCs assume that cooperative group learning observed in FTF classrooms can be replicated in online environments. However, to the knowledge of this author, no definitive evidence has yet been reported that OLC contexts promote cooperative learning in a manner comparable to learning benefits observed in cooperative FTF contexts. Moreover, as suggested previously, research by the educational community on group learning has largely ignored contributions of E/HF research to understanding learning performance in social and team contexts. Accordingly, this section outlines a cybernetic perspective on learning and applies these concepts to social learning, with the goal of delineating how approaches to learning performance analysis, and to designing online interfaces to benefit such performance, can be applied to OLC environments.

Cognition and learning have common behavioral and neurobiological substrates [20]. Cognition—perception and knowing—manifests itself through a variety of behavioral phenomena, denoted by terms such as thinking, problem-solving, understanding, insight, planning, situation awareness, mental workload, and so forth.

<u>Projective control principle</u>. In cybernetic terms, what these different manifestations of cognition have in common is predictive activity, which represents the essence of cognition. In other words, for effective guidance of behavior you have to be able to predict the sensory and perceptual consequences of your actions [21,22]. This principle assumes that both cognition and learning rely upon behavioral control of future behavior, a process termed feedforward control, anticipatory control, or projective tracking. Projective control involves the cognitive projection of past memories and sensory feedback experience to anticipate future events and the behavioral requirements for their control, so that control actions can occur to prevent behavioral errors from occurring when these events transpire. Based on empirical studies of brain function, neuroscientists now believe that such predictive guidance is based on what is termed a forward model, in which memory of sensory feedback from past action (the predictive model) is referenced against real time sensory feedback from current action (perception), and the model updated (learning) based on any detected discrepancy.

<u>Motor control of cognition and learning</u>. This principle assumes that cognition and learning depend

upon effective motor behavioral control of sensory feedback [13,17,23]. Cognitive demands as they are commonly experienced can be understood as resulting from challenges to such feedback control caused by complex sensory environments (control limitations), lack of learning (poor understanding), lack of skill (poor training), and/or poor human factors design. In every case, the consequence is a compromised ability for projective guidance of behavior.

Context specificity in cognition and learning. The essence of this principle is that the preponderance of observed variability in cognitive and learning performance is attributable, not to inherent biological factors or learning ability, but to design of the task [14]. In other words, such performance cannot be evaluated outside of its context---generalized models of performance have little scientific validity. Firm empirical evidence for this conclusion was first compiled almost a century ago from differential learning studies. The authors cited above review other evidence from research on psychomotor performance, causes of industrial accidents, effects of displaced sensory feedback, and social tracking, that also supports this conclusion. The key implication of this principle for this report is that the nature and extent of learning is prominently influenced by ergonomic design features of the learning environment [1,6].

4. Empirical studies of social tracking and learning

Empirical social cybernetic research on social tracking and learning demonstrates that the general cybernetic principles of cognition and learning outlined above, based on studies of individual performance, also are directly applicable to social performance and learning. Key findings are as follows [14-18].

1. Context Specificity in Social Tracking Performance. As with individual performance, the preponderance of observed variability and specialization in social tracking performance is attributable, not to biological or learning ability factors, but rather to the influence of the human factors design of the tracking task and interface. Design factors of significance that may be specified include sensory feedback control parameters and conditions, mix of tracking modalities employed, temporal and spatial properties of sensory feedback, and the level and pattern of interpersonal, group, institutional, and/or human-system social relationships (Fig. 1).
2. Sensory Feedback Modality and Social Tracking Proficiency. Relative to visual-manual social tracking, accuracy and proficiency are greater for tactile, kinesthetic, and auditory social tracking. Social tracking based on nonverbal sensory feedback often is more effective than verbal tracking in promoting social learning and communication. For all sensory modalities, the accuracy of interactive social tracking is comparable to that of individual tracking except under feedback delay conditions, when the latter is superior to the former at all delay levels. Mutual social interaction entailing reciprocal exchange of sensory feedback (series- or parallel-linked tracking) is more effective than purely imitative tracking.
3. Effects of Sensory Feedback Perturbations on Social Tracking. Real time temporal delays or spatial displacements in sensory feedback severely degrade the accuracy of social tracking performance, just as they do for individual tracking performance. Therefore, as with individual behavior, the integrity of social behavior also relies upon the ability of each partner to effectively control the temporal and spatial qualities of sensory feedback generated during the social tracking process.
4. Social Tracking Among Members of Multi-Person Teams. Because of the introduction of additional sources of sensory feedback to control, the demands and complexity of social tracking in groups involving more than two people rapidly escalate.
5. Social Cybernetics of Cognitive Behavior and Communication. Interactive social communication, with its pronounced motorsensory feedback control demands, is central to all modes of cognitive behavior and represents the principal determinant of effective learning of cognitive skills.
6. Social Psychophysiological Compliance (SPC). Coordinate motorsensory control by team members in a collaborative social tracking task is known to have reciprocal effects on the psychophysiological state of each team member, a phenomenon termed SPC [9]. SPC measures have focused on coordinate patterns in heart rate, breathing, and electrodermal activity among multiple team members. Laboratory studies reveal that SPC measures are predictive of both present and future team performance on a projective tracking task. The evidence suggests that spatiotemporal compliance in both motor behavioral and physiological dynamics established

among team members facilitates social tracking generally and team projective control specifically.

7. Learning of Social Tracking Skills. Finally, of immediately relevance to this report, social learning of specific social tracking tasks is highly variable, relatively limited and inconsistent, and unstable, even with provision of real time feedback of tracking performance.

What is the relevance of the foregoing points for understanding the potential for cooperative learning in OLCs? The principle of context specificity (Point 1) implies that patterns of variability in learning performance of FTF groups will differ significantly from that of OLCs. Individual differences in asynchronous learning performance of individuals has received some attention [24,25], but questions of the nature and extent of context specificity in OLC group learning, and of which OLC interface design factors critically influence such learning, remain unexplored. One particular question of interest is which mode or modes of social tracking (Fig. 1) will best support OLC performance.

Lack of availability of tactile and kinaesthetic feedback in virtual space may be assumed to compromise OLC relative to FTF group learning (Point 2), given that OLC interaction relies primarily on visual feedback. It is likely that the availability of multiple modalities of sensory feedback facilitates SPC and social tracking integration in FTF groups (Point 6), pointing to a need for interface design innovations to allow for different modes of sensory feedback exchange among OLC members.

Spatial and temporal displacements in sensory feedback (Point 3) are inherent to online interfaces, with adverse consequences for student learning with asynchronous networks [8]. Interface design techniques to mitigate such effects will be required to promote effective OLC group learning.

This brings us to the question of social learning itself in FTF versus OLC groups. The analysis of Johnson and colleagues [26] indicates that cooperation is superior to interpersonal competition or individual effort in promoting achievement and productivity. However, this work did not address the question of the persistence and stability of learning achievement over time, which social cybernetic research has shown to be compromised in social relative to individual learning (Point 7). It is likely that the cognitive demands of social tracking in multi-person groups (Point 4) will tend to exacerbate the labile nature of social learning.

5. Interface design strategies to promote OLC performance

The foregoing analysis points to a series of interface design strategies that likely will benefit the learning performance of OLC groups.

- Provide for exchange of multiple modes of sensory feedback among group members.
- Reduce spatial and temporal displacement in sensory feedback to the extent possible during social tracking among group members.
- Consider SPC analysis [9] to assess both social tracking integration and social learning.
- Model incremental gains in group learning achievement with the law of training, one of the most robust predictive behavioural models in psychology [27].
- Create virtual displays to enable OLC participants to track the behavioural (and possibly physiological) status of each other in real time.

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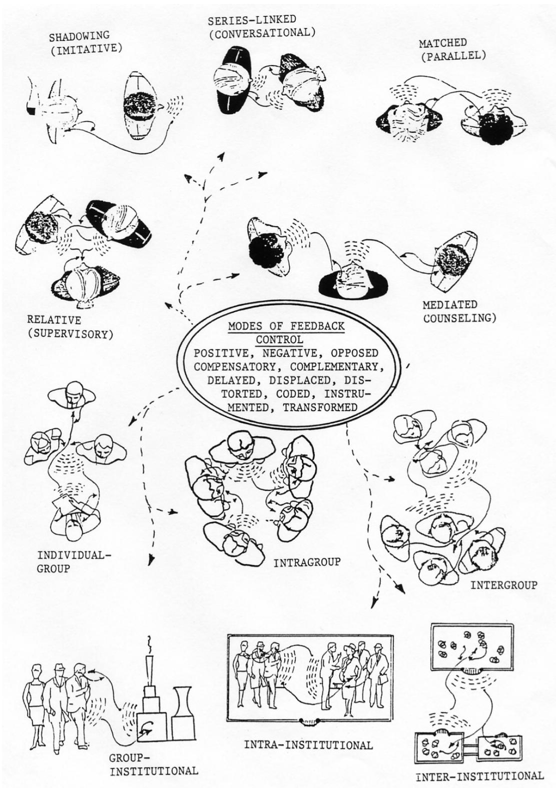

Fig. 1: Different modes of social tracking