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ABSTRACT

The Teacher Professional Development Institute employs Internet technology to support distributed professional learning communities. The Secondary Teacher Education Program (STEP) at the University of Wisconsin-Madison will soon employ a similar model in its program. Work and learning within STEP evolves around instructional design teams comprising pre-service teachers and various advisors. Because much of this work is project-based rather than curriculum driven, traditional assessment is not appropriate. Our approach involves taking advantage of the online environment's ability to collect data on collaborative process. To help determine standards of evidence appropriate for judging groups as knowledge-construction entities, we articulated a theoretical framework based on four accepted views of social knowledge construction. Assessment was conceptualized as abductive inference, case identification given particular theories and relevant evidence pertaining to them. The theories predict indicators that can be represented as nodes linked by subjective probabilities within a Bayesian network. Observable features of online interactions provide input to the Net. Outputs are probability distributions indicating the degree to which a group meets normative standards described by theory. The network can produce general assessment and diagnostic profiles for groups and subgroups within large communities. (Author/SAH)

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Assessing Knowledge Construction in On-Line Learning Communities

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TABLE OF CONTENTS

I. ABSTRACT

II. INTRODUCTION

III. DESIGNING AN INSTRUCTIONAL PROGRAM WITHIN AN ON-LINE ENVIRONMENT

IV. THE ASSESSMENT CHALLENGE

V. A THEORETICAL FRAMEWORK FOR PROCESS ASSESSMENT OF ON-LINE INTERACTION

VI. ASSESSMENT AS ABDUCTIVE INFERENCE IN A BAYESIAN NET

VII. FIGURES

VIII. TABLES

IX. REFERENCES

Abstract

The Teacher Professional Development Institute employs Internet technology to support distributed professional learning communities. The Secondary Teacher Education Program (STEP) at the University of Wisconsin-Madison will soon employ a similar model in its program. Work and learning within STEP evolves around instructional design teams comprising pre-service teachers and various advisors. Because much of this work is project-based rather than curriculum driven, traditional assessment is not appropriate. Our approach involves taking advantage of the on-line environment's ability to collect data on collaborative process. To help determine standards of evidence appropriate for judging groups as knowledge-construction entities, we articulated a theoretical framework based on four accepted views of social knowledge construction. Assessment was conceptualized as abductive inference, case identification given particular theories and relevant evidence pertaining to them. The theories predict indicators that can be represented as nodes linked by subjective probabilities within a Bayesian network. Observable features of on-line interactions provide input to the net. Outputs are probability distributions indicating

- the degree to which a group meets normative standards prescribed by theory. The network can produce general assessments and diagnostic profiles for groups and subgroups within large communities.

Introduction

New educational approaches are emerging that employ Internet technology to support collaborative environments for distributed professional learning communities. One example is the Teacher Professional Development Institute (TAPPED IN, or "TI" for short), although other examples have recently emerged in a variety of professional fields. When users log into the TI environment on the web (http://www.tappedin.org) they are located, virtually, in an institute. The institute is based on a building metaphor with floors, offices, meeting rooms, and other spaces that a physical institute would have. The virtual spaces of TI provide places where teachers can "meet" and where artifacts can be created and stored. The existing TI membership of over 2000 educators provides a broad national community basis for teacher professional development through collaborative learning [1].

Designing an Instructional Program within an On-Line Environment

Inspired by the TI example, our research group is helping restructure the Secondary Teacher Education Program (STEP) at the University of Wisconsin-Madison in accordance with a distributed professional learning community model. Briefly, work and learning within STEP evolves around instructional design projects that students develop to partially fulfill their course requirements. Each student in the program participates on one or more teams. Students direct the teams but are advised by various mentors who share in teamwork. Mentor-participants include in-service teachers in whose classrooms the STEP instruction will be evaluated; university faculty from the School of Education; and experts in subject-matter disciplines that are relevant to each team's instructional projects.

The personal goal for each student within a team should be to acquire knowledge about teaching by applying course ideas in actual design practice. The community goal for each team is to contribute to their learning communities' (both STEP and TI) growing bank of instructional resources and best-practice cases in educational problem solving. Because members of teams are geographically dispersed, it is expected that more and more STEP teams will elect to meet and work within the TI (or a similar alternative) environment.

The Assessment Challenge

A major aspect of the research reported here involves developing new methods for automated or partially-automated assessment of the collaborative work that takes place within on line learning communities. There are many reasons why learning community approaches to education require radical new assessment models. First, because much work within learning communities is project-oriented and inquiry based rather than curriculum driven, the goals of instruction are variable across individuals and groups and are largely determined by learners themselves. Since learning outcomes are difficult to specify in advance and are not highly predictable, traditional methods of testing are not highly appropriate. A common alternative involves evaluating tangible group or individual products that result from group work. For example, members of project teams might submit, for evaluation, web sites documenting group projects or portfolios documenting individual development resulting from group participation. A third, less-explored alternative involves taking greater advantage of the on-line environment's ability to collect data on collaborative process, which is the goal of the work reported here. By combining standard AI techniques and frameworks based on current cognitive theories of group interaction, we are mining on-line data to obtain evidence for drawing inferences about the quality of on-line work.

We believe a comprehensive assessment framework for instruction should include evaluation of both tangible and intangible cognitive products. However, there are many reasons to develop a process assessment methodology as well. One motivation is that on-line learning communities often grow quite large and become too unwieldy for supervising teachers to monitor. A reporting system based on process assessment can greatly aid teaching, mentoring, and other forms of supervision and network facilitation. For example, process assessment can help identify students whose frequencies and patterns of interaction are problematic. Through early identification and diagnosis of process deficits, teachers or other types of mentors (both human and machine) can monitor a large communication net and direct tailored guidance to specific people and groups in need of attention.

A Theoretical Framework for Process Assessment of On-Line Interaction

We assume that educators, researchers and developers who work with on-line learning communities want to foster high-level discourse that supports growth of knowledge within communities, not just social chat. To help determine what standards of evidence are appropriate for judging group process on this basis, we developed the theoretical framework summarized in Figure 1 . Figure 1 represents a synthesis of four cognitive viewpoints regarding the nature of social knowledge construction. We assume that this basic framework can be applied at different grain sizes, that is, to small working groups and to larger Internet communities. It is most applicable to relatively stable long-term groups that pursue work goals, though some turnover is assumed. The framework is less applicable to short-term, ad hoc groups with vague objectives.

A sociocultural/situative viewpoint [2,3] dominates this framework. From this view, knowledge construction is indicated when key "boundary constructs" [4] evolve into mutually understood "new" ideas, behavioral norms, and other intangible constructs that shape and are shaped by teamwork. Boundary constructs are ideas brought to the problem initially by members of diverse backgrounds, and are so named because they represent shared general ideas within overlapping boundaries of disciplinary knowledge. Documentation that boundary constructs have emerged, evolved and supported group work is evidence that a knowledge-construction system exists. In addition, sociocultural/situative theory implies that the processes of negotiation and apprenticeship drive knowledge construction, viewed as boundary construct evolution. Hence, measures reflecting the presence, frequency, and quality of these processes within work groups and their larger communities provide evidence for their efficacy as knowledge construction entities.

Figure 1 also represents a sociocognitive perspective, so named because it views knowledge construction as an individual cognitive activity that is driven by social interaction. Knowledge construction is seen as involving changes and realignments in individuals' mental representations that are associated with their work. Theoretically, as team members work together their individual mental models of group tasks, community constructs, and the community itself become more aligned with one another. A substantial degree of mental-model alignment is considered a necessary precondition for productive work, although some misalignment is desirable [5,6] . When people with different points of view work together, their interactions produce cognitive conflicts that lead to argumentation, which in turn drives conceptual change. Hence, from the sociocognitive perspective, insurance that communities are operating as knowledge construction systems must be based on evidence of conceptual and belief change within individuals, and on evidence that there is a trend toward increasing compatibility among members' viewpoints.

The model also assimilates a literature that sees knowledge construction as both process and product of argumentation and informal scientific reasoning. This "critical thinking" [7] viewpoint suggests that negotiation processes should be judged against established standards for argument form and content, recognizing that argument in conversation is both temporally and socially distributed [8]. It also suggests that the knowledge resulting from valid argument is superior to knowledge resulting from less logical processes. Hence, "respect for good argument" should be a measurable social norm within knowledge building communities. The degree of adherence to critical thinking norms can theoretically be detected and measured in studies of conversation patterns and individual beliefs. We believe, however, that valid argument in on-line conversation may be infrequent and difficult to detect [9]. Both training and on-line tools may be needed to scaffold good argumentation within on-line learning environments. If such tools were available, on-line patterns of use associated with them could help us evaluate groups on the basis of their argumentation strategies and their tendency to base judgments and decisions on evidence and valid argument. Such tools do not currently exist within TI but could be added.

Finally, Figure 1 incorporates group information processing theory [10,11]. From this view, assessments of groups as knowledge construction entities must consider the processes by which information is shared and transformed from one form (e.g., private, unshared knowledge) to another (e.g., a tangible group product). Theoretically, successful sharing increases group knowledge and knowledge distribution; hence measures showing progressively greater and deeper conceptual alignment among members are valid indicators from the information processing viewpoint (as they are from the sociocognitive one). Assessment designs based on the group IP perspective can capitalize on research pointing to specific factors known to shape group information processing. These include social factors, such as status of individual members. For example, a composite score indicating high cultural/professional diversity within groups (indicative of broad knowledge capacity) AND high levels of sharing among all social-status categories is one theoretically-sound index for comparing and judging groups as knowledge-construction systems. Other factors shaping group information processing include behaviors and contexts that impact important information processing phases, such as the attentional phase. For example, one useful comparative index is derived from observable signs of group attention deficits. These occur because environmental events (e.g., phone calls) frequently distract members from on-line conversations. However, the value of this index can be adjusted if there is evidence that members employ technological features of on-line environments to compensate for attentional deficits. For example, members may use an environment's recording capabilities to review missed conversation.

Assessment as Abductive Inference in a Bayesian Net

Although our theoretical framework is presented as an integrated one, the assessment techniques that follow from the four constituent theories differ from one another. For example, the situative model suggests that if groups are operating successfully, certain classes of discourse patterns, such as negotiation and apprenticeship, must be observed. The measured frequency or strength of such interactions within a prescribed corpus of interactive data can help predict the extent to which the group is successful as a knowledge construction system. But while the sociocultural/situative view leads to examination of teamwork from observable discourse processes, the sociocognitive view leads to protocol, interview and questionnaire techniques that permit researchers and teachers to look inside participant's heads—to examine belief change. These data can also be collected on line.

Assessment thus conceptualized is viewed a problem of abductive inference, or case identification given particular theories and relevant evidence pertaining to them. Because case identification is indiscrete and continuous, we employ a Bayesian probabilistic framework [12]. The theories predict indicators that can be represented as nodes linked by subjective probabilities. Indices and codes representing observable features of on-line interactions and tool use provide input to the net. Outputs are propagated probability distributions indicating the degree (e.g., strong, medium, weak) to which a target group meets normative standards prescribed by each of the four theories. Although these distributions are derived from subjective probabilities and thus cannot be interpreted absolutely, they are grounded in theory, constant, and comparable across groups as normative indices. The network can thus produce both general assessments and meaningful diagnostic profiles for groups and subgroups within large communities.

To illustrate how this type of network can be used in assessment of online interaction, we present an example based on two groups that met regularly in TI. On the day selected for this example, the two groups met at the same time (one for around 40 minutes, the other for around 60 minutes) in different virtual rooms to discuss different topics related to education. The first 40 minutes of each meeting were analyzed to identify the meeting's Group Attention Index, which comprises a branch of the overall network assessing a group's information processing ability.

Table 1 and Table 2 show excerpts taken approximately 15 minutes after the start of each group's meeting. The columns differentiate between shared text (seen by all participants), and private text (including whispers and other commands seen only by the speaker and any designated recipients).

In these excerpts, Group A discussion posed fewer attentional demands than Group B. In Group A, while some comments were out of sequence (i.e., prompted by a turn not directly above it in the window), all comments were both shared and on-task. In contrast, Group B faced multiple potential distractions. The first line shows a user apologizing for having technical difficulties. Whispers were exchanged among four participants (NL, NR, CS, and BL) on 5 different topics (a previously discussed issue [5:00]; AOL [5:32; 6:34, 7:54]; norms of whispering [5:38]; a problem with "J" [6:35, 7:58]; and an out-of-sequence statement [7:45]). Even the whispers overlapped, with participants NL, CS, and BL involved in multiple out-of-sequence whispers. As a result, members of Group B needed to interpret multiple threads of conversation—some unrelated to the topic being discussed—amid technical disruptions and errors.

The differences between Group A and Group B were quantified using the "Deficits" portion of the probability network as shown in figure 2, which is a sub-branch under the Group Information Processing Attention branch of the network. The group attention deficit index (Deficits) was defined as a combination of tool-related deficits (Tool_Deficit), group-level distractions (Grp_Distract), and multiple threads in the conversation (AttnToMT). (Note that for display purposes, the tool deficits and group distraction sub-branches are shown separately in the diagram).

For each 10-minute interval, we computed per-person averages for involuntary disconnects, early exits, etc., and entered the averages as input to the network. Each node in the network shows the probability that the node is in a particular state (high/medium/low). The input nodes determined the states of their parent nodes, which in turn propagated up to determine the state of the overall attention deficit index. As the Deficits nodes indicate, group A had a low degree of attention deficits (64% probability of low deficits; 31% of average deficits; 5% of having high deficits). In contrast, group B had higher attention deficits (59% probability of high deficits; 32% probability of average deficits, and 9% probability of low deficits). In the larger group attention network (not displayed here) these probabilities resulted in group A having 59% probability of being a high-attention group and group B having only a 19% chance of being a high attention group. These results support the differences shown qualitatively in the transcript excerpts.

We are in the process of refining the probability network based on the analysis of additional group meetings. Refinements are being made both in the network probabilities (e.g., what combination of values in input nodes results in a "high" , "medium", or "low" value for a parent node) and in the thresholds for determining input values (e.g., what input qualifies as a "high", "medium", or "low" percentage of whispers per total turns). At this point, many indices (such as percentage of errors) can be calculated based on information captured online, while others—such as thread count—currently require some human processing. However, the amount of human pre-processing will gradually be reduced as coding systems and algorithms for machine processing are developed.

Footnote

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Figures

Figure 1. Theoretical Framework Back.

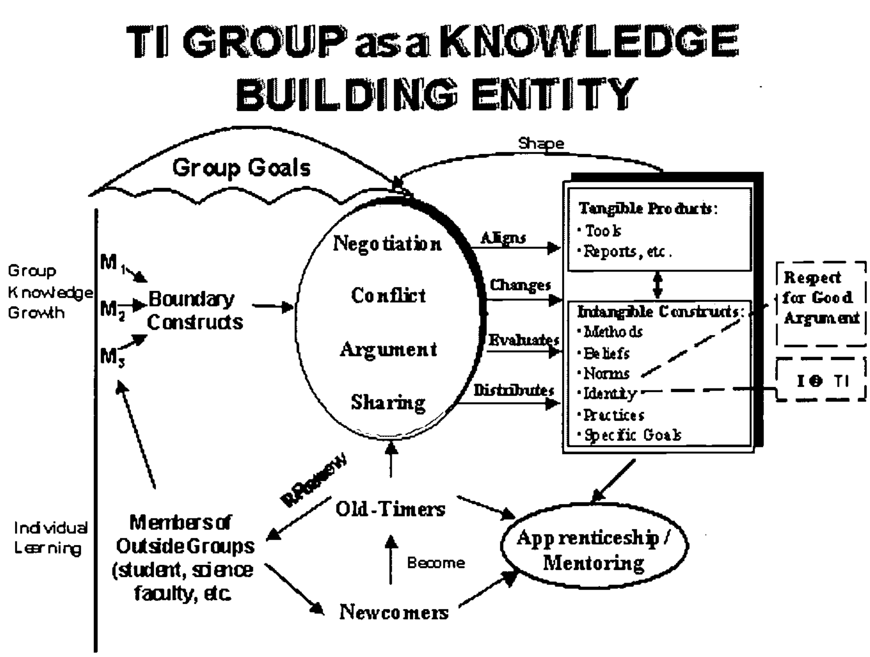
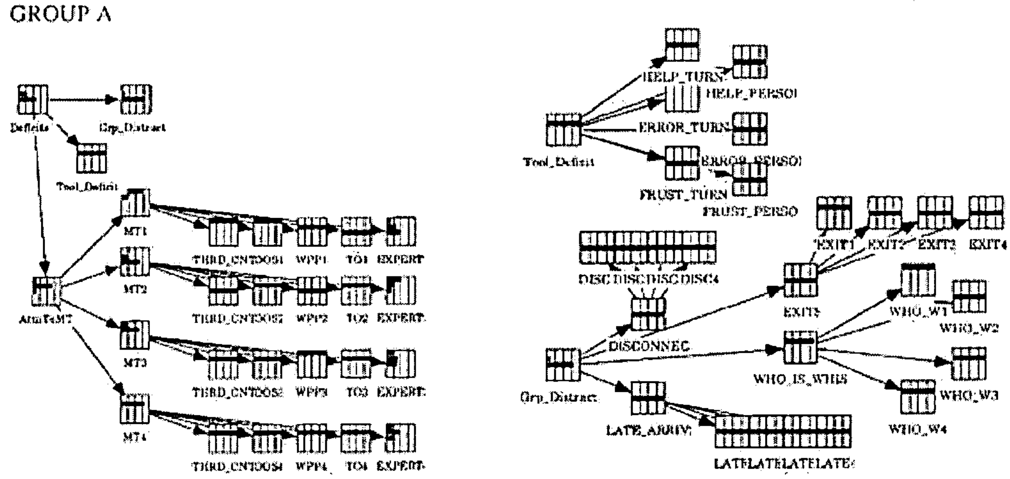
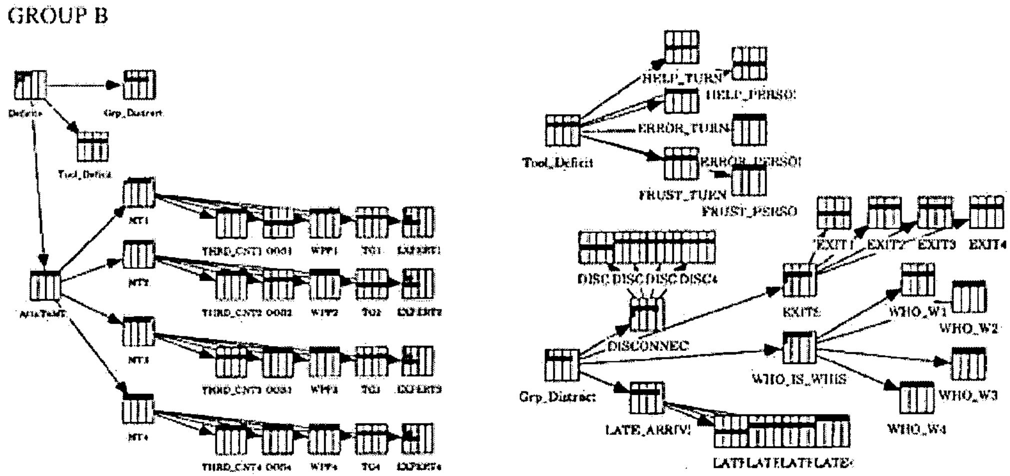


Figure 2: Probability Networks for Deficit sub-branch for Groups A and B. Back.

GROUP A



GROUP B



Tables

Table 1: Excerpt from Group A's Conversation. Back.

6:26	BL	And with a little explanation, more were able to see the light.
6:41	HC	think it is important to ask high level questions for all kids
7:04	AE	:agrees with HC
7:19	HC	they surprise you!
7:30	RK	yes they do sometimes
7:32	HT	We are readilng one tf the core books for 4th right now and it is hard to get them to go beyond the basics.
7:32	BL	YES!!! Pleasantly so.
7:38	AE	i've seen some classrooms where the teacher actually posts the beginning of questions to remember
7:52	HC	:has those in the back of her room
7:52	BL	I would like to try that next year.

Table 2: Excerpt from Group B's Conversation. Back.

Time	Spkr	Shared text	Private text
4:40	CS	Sorry folks---I have AOL. It likes to dump me off."	
4:42	AL	Time management is a lot like math. The more organized and logical I am, the smoother my day goes. I waste very little time. This allows me relax and down time	
4:50	NL		Page DJ Thanks... she got it
5:00	NR		(to NL) "thank you
5:01	BL	CS do you have aol loaded at work?	
5:03	CS		<who>
5:04	NL	Let's be more specific about that AL	
5:21	NL	I notice that you really are organized, can you elaborate?	
5:32	CS		(to BL) NO, I'm at home..."
5:38	NL		(to BL) Remember to whisper if you're off topic. ok?
6:12	AL	I try very hard not to waste steps or precious moments. I go through my mail over the waste basket. I dump what is not needed so I don't have these huge piles. I keep files with things organized	
6:15	CS	I know that I forget anything I don't write down...I even have to E-mail myself sometimes.	
6:34	BL		(to NL) You mean AOL isn't a legitmate use of time mangenent ?<w>
6:35	NL		(to BL) Did we get the situation with J worked out?
6:39	NL	:nods	
6:41	CS	SO AL--it sounds like those little time savers you do add up to big time savings overall...	
6:59	CS	OK--How about saving time with this:	
7:01	AL		<error>

7:05	NL	NR, you're an old timer at this school teaching business... what ideas do you have?	
7:06	CS	(projects prepared text)	
7:10	BL		(to NL) He looks pouty but he hasn't complained :)
7:45	CS		(to NL) "Didn't mean to step on your toes..."
7:54	BL		(to CS) have you asked about loading aol at school?
7:58	NL		(to BL) I think it's totally your call unless he wants to complain to higher authorities

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