Cognitive-Based Guidelines for Effective Use of Collaboration Tools

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TC3 Workshop
Cognitive Elements of Effective Collaboration
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Cognitive-Based Guidelines

Topics

• Collaboration tool guidelines
  - Opportunity
  - Taxonomies

• Theoretic foundations--the models
  - Purposes
  - Diversity
  - Transactive memory

• Validation
  - Strategies
  - Metrics
Collaboration, as used in this analysis, is

the mental aspects of joint problem solving for the purpose of achieving a shared understanding, making a decision, or creating a product
Opportunity

• Conditions for highly effective teamwork nearly in place
  - Rich set of collaboration tools
  - High communication connectivity
  - Understanding of cognitive basis of effective teamwork

• However, collaborating teams sometimes do not work well

• Therefore, guidelines for effective collaboration can have a significant impact
Guidelines
Examples from Current Sources

Task/Communication Mode Example (Jens Jensen)

<table>
<thead>
<tr>
<th>Communication Modes</th>
<th>Generating ideas and plans and collecting data</th>
<th>Problems with answers</th>
<th>Problems without answers</th>
<th>Negotiating technical or interpersonal conflicts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audio only</td>
<td>Marginal fit</td>
<td>Good fit</td>
<td>Good fit</td>
<td>Poor fit</td>
</tr>
<tr>
<td>Video only</td>
<td>Poor fit</td>
<td>Good fit</td>
<td>Good fit</td>
<td>Marginal fit</td>
</tr>
<tr>
<td>Data only (e.g., e-mail..)</td>
<td>Good fit</td>
<td>Marginal fit</td>
<td>Poor fit</td>
<td>Poor fit</td>
</tr>
<tr>
<td>Multi-user virtual</td>
<td>Good fit</td>
<td>Good fit</td>
<td>Good fit</td>
<td>Good fit</td>
</tr>
<tr>
<td>environment</td>
<td></td>
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</tbody>
</table>

- "Expertise location software, audio conferences, web conferences, and other interactive technologies can be as effective as databases for sharing tacit knowledge.
- Intranets can be powerful tools for tailoring information and improving organizational performance.

Mary Boone. Managing Inter@ctively. Page 159
Taxonomies for Collaboration Environments

- Characterizes types of collaborative tasks, teams, and tools
- Describes collaboration space
- Provides framework for specifying when to apply different types of guidelines
Team Taxonomy Dimensions

• Distribution
• Roles and Functions
• Team Structure
• Team member dependencies
• Information and Information Flow
• Decision Making
# Team Taxonomy Examples

<table>
<thead>
<tr>
<th>Team Dimension</th>
<th>Dimension Subcategories</th>
</tr>
</thead>
</table>
| Distribution   | • Physical—spatial separation  
                 • Temporal—e.g., working different shifts  
                 • Expertise—spatial and temporal distribution of experts and expertise  
                 • Information—spatial distribution of information |
| Team Structure | • Hierarchical vs. flat—extent that team has designated leader in charge or is peer-to-peer  
                 • Size—number of members  
                 • Permanent vs. ad hoc—extent it works together over extended period of time, or is brought together for one task  
                 • Single vs. team-of-teams—extent that teams can be decomposed into collaborating sub-teams  
                 • Turn-over—stability of team membership |
| Team member dependencies | • Independence—extent that each team member depends on other team members to perform his task  
                            • Interaction frequency—how often team members must interact  
                            • Synchronization—requirement for and schedule tolerance of temporal sequencing of tasks performed by different members  
                            • Cognitive—extent that team members must pay attention to each others’ tasks  
                            • Task sharing—extent to which each team member has own task or all team members share the same tasks  
                            • Processing flow—individual/parallel or sequential |
Task Taxonomy Dimensions

- Cognitive domain
- Workload
- Divisibility
- Difficulty
## Task Taxonomy Examples

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<th>Dimension Subcategories</th>
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| **Cognitive domain** | • Stage(s) of decision making emphasized--goal specification, monitoring, situation diagnosis, opportunity/problem ID, alternative ID, alternative evaluation, selection  
• Interaction focus--info exchange, brainstorming, review, negotiation, consolidation, handoff |
| **Workload** | • Effort--amount of work required to carry out team assignment  
• Duration--length of time over which work must be performed  
• Expertise—amount of expertise work requires for successful completion (extent that work requires specialists)  
• Degree of reach--extent that assigned work requires tasks carried out at different places and at different times |
| **Difficulty** | • Goal clarity--extent that objectives are well defined  
• Resource clarity--extent that available resources are well specified  
• Stakes--importance of the outcome  
• Familiarity—extent that tasks are routine or novel  
• Information availability--extent that needed information is readily available  
• Time pressure--extent that task has hard real or perceived deadlines  
• Transparency--the ease or difficulty required to monitor the tasks status or progress  
• Stability—extent that tasks, resources, and information requirements may change in response to new opportunities and problems |
Tool Taxonomy

• General purpose group communication tools
  - E-mail, video and audio conferencing, shared white board, shared documents and databases, bulletin boards, news groups, web pages, “sticky notes,” chat rooms

• Special purpose facilitators of group processes
  - Electronic meeting systems, brainstorming, negotiation, review and editing, idea enrichment tools

• Shared work and group sense making tools
  - Tailored interactive visualizations of shared data

• Process support tools
  - Workflow managers, electronic document management, calendar support, collaborative planning, plan monitors, dialog managers, audit trail managers, expert finders, mail lists
Modeling goal: Describe mechanisms that connect individual understandings to the quality and timeliness of team products and to team efficiency.
Need for Complementary Collaboration Models

• No model can likely address all aspects of collaboration
• However, a set of complementary models, each addressing different aspects of the same underlying process, can
• Five models of value to the SBIR are
  - **Teamwork and Taskwork**: all teams engage in activities to develop tasked product and to maintain team health
  - **Feedback**: teams must monitor progress and make corrections for both teamwork and taskwork
  - **Individual/Team Interplay**: many collaborative tasks call for a cycle of individual and group processes
  - **Coupling Cognition, Behavior, and Products**: team processes and products emerge from individual understandings, behaviors, and products
  - **Transactive memory**: the relationship among team member’s individual understandings drives the quality of team performance
## Complementary Collaboration Models

<table>
<thead>
<tr>
<th>Teamwork</th>
<th>Taskwork</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team organization and maintenance</td>
<td>Accomplishing mission goals</td>
</tr>
</tbody>
</table>

### Teamwork
- Organize for teamwork
  - Agree on goals
  - Identify tasks
  - Assign roles
  - Develop schedule
  - Identify interaction criteria and methods

### Taskwork
- Develop mission
  - Analyze mission
  - Identify tasks
  - Allocate tasks
  - Develop schedule
  - Assign resources
  - Identify constraints
  - Develop contingencies

- Execute mission
  - Monitor
  - Assess situation
  - Decide on needed plan adjustment
  - Issue directives
  - Execute / develop products

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### Individual vs. Team

- **Prepare**
  - Notice need for interaction
  - Prepare for interaction

- **Execute**
  - Perform task

- **Interact**
  - Negotiate
  - Brainstorm
  - Critique
  - Discover differences
  - Enrich ideas
  - Guide
  - Distribute
  - Decide and disseminate

### Tools
- Person directed questions & answers
- Shared visualization
- Shared documents

### Products
- Work required to use tools

### Other non-cognitive impacts on behavior

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### Diagram

- **Prepare**
  - Develop/revised team organization and procedures
  - Analyze team mission

- **Execute**
  - Diagnose need for plan adjustments
  - Monitor mission progress

- **Team**
  - Attend to team health

- **Individual**
  - Understand needed to do task

- **Individual Behavior**
  - Understand acquired from doing the task
Transactive memory is the distribution of knowledge within a team. It functions as a powerful intervening variable between group discussions and group behaviors.
Transactive Memory Model

Transactive Memory System

Individual Understandings
- Background understanding of job and team
- Real time performance assessment
- Required actions

Team Develop Consensus
- Exchange information to develop and align individual understandings
  - Negotiate
  - Brainstorm
  - Critique
  - Discover differences
  - Enrich ideas
  - Guide
  - Distribute

Team Assemble the Product
- Synchronize
- Adjust
- Assemble
- Team Product

Individual Contributions to Products
- Feedback
# Individual Understandings

Organize to Support Teamwork and Knowledge Sharing

<table>
<thead>
<tr>
<th>Meta memory</th>
<th>Private memory</th>
<th>Shared information</th>
<th>Transactive information</th>
<th>Consensus items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team member’s assessment of his ability to recognize when knowledge is needed and to recall and use his knowledge</td>
<td>What team member knows about that though not expected to be needed in this particular joint action could be critical</td>
<td>Items that a person is responsible for knowing within the team, and that others know he’s responsible for. Multiple team members can share responsibility</td>
<td>Items team member knows that somebody else is responsible for, and knowledge of how to obtain that information</td>
<td>Things that the team has decided</td>
</tr>
</tbody>
</table>
Guideline Validation

• Strategies: a combination of
  - Assessments of experienced practitioners
  - Observations from exercises or wargames with “natural” control
  - Hypothesis testing experiments with control group
  - Validation of model/theory that guidelines are based on

• Metrics are key element of validation
## Metrics

<table>
<thead>
<tr>
<th>Individual Understandings</th>
<th>Individual Information Interaction Support</th>
<th>Individual Task Performance</th>
<th>Individual Products</th>
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<tr>
<td>Team Understandings</td>
<td>Group Information Interactions</td>
<td>Teamwork</td>
<td>Team Products</td>
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</table>
Metrics
Product and Team Efficiency

• Bottom line “proof of the pudding” metrics
• Metrics for a particular product are the same, whether produced by an individual or a team

• Examples
  – Product timeliness
    • Timeliness of product production--product completion time relative to deadline
  – Product quality metrics (plan example)
    • Useful life of plan compared to its intended useful life. No plan “survives contact with the enemy,” but better plans last as long as intended
    • Fraction of commander’s objectives that plan addresses
    • Fraction of plausible contingencies covered by plan
  – Team efficiency
    • Total amount of time required to complete the product
    • Person hours to complete product
Metrics
Individual and Team Task Performance

• Individual
  - Measures individual performance in task performance,
  - Behavior categories: task performance, workload, level of engagement, schedule adherence, problem handling, and task flexibility
  - Metric examples
    • Fraction of individual tasks started late
    • Fraction of person’s delivered products needing revision

• Team
  - Measures team behaviors
  - Includes roll-ups (computed from individual metrics) and emergent behaviors (not an aggregation property of an individuals’ behaviors)
  - Emergent behaviors: team agility, synchronization, “fibrillation,” and “friction”
  - Metric examples
    • Time required for team to recognize a problem in teamwork or product development
    • Fraction of preliminary individual products never used

• Examples
  - Fraction of messages received that are relevant
  - Number of cases where sub-teams refuse to share information relevant to others
  - For synchronous collaboration, number of incidents requiring participation by team members not at the meeting
  - Extent that homogeneous, conventional speech patterns used
Metrics

Individual and Team Information

Interactions

• Individual
  - Measures individual performance to support development of group consensus
  - Includes information acquisition, formulation, and dissemination
  - Metric examples
    • Fraction of times right person asked for information
    • Fraction of time information needed by others conveyed in ways that could be understood without need for clarification

• Team
  - Measures behaviors for consensus building
  - Includes team member participation in brainstorming, idea enrichment, discovery of differences, negotiation
  - Metric examples
    • Fraction of differences in understanding identified
    • Fraction of time spent in meeting not relevant to own responsibilities and not contributing to others
Cognitive Metrics

- **Individual metrics**
  - Team member understanding of status and processes for teamwork and taskwork
  - Organized into seven cognitive categories
    - Goal formulation, monitoring, situation diagnosis, opportunity/problem identification, identification of candidate actions, evaluation of these candidates, actions selection
  - Examples
    - Correctness of team member understanding of commander’s intent
    - Correctness of knowledge of deadlines of decisions
    - Correctness of common ground elements (next slide)

- **Team Level metrics**
  - Three types
    - Roll-ups average individual cognitive metrics
    - Team coverage measures best knowledge in team and gaps
    - Alignments summarize extent of shared understanding
  - Examples
    - Average accuracy of each team member’s estimates of information needed by other team members
    - Consistency and overlap of shared understanding of problem, goals, information cues, and strategies
Generating Collaboration Guidelines

Team and Task Types → Common Problems (ineffective behaviors) → Theory and models of collaboration

Hypothesized cognitive causes (transactive memory problems) → Hypothesized methods to fix causes → Candidate Guidelines

Metrics → Validation Process → Validated Guidelines
Backups
# Model 1: Teamwork and Taskwork

## Teamwork

**Prepare**
- Organize for teamwork
  - Agree on goals
  - Identify tasks
  - Assign roles
  - Develop schedule
  - Identify interaction criteria and methods

**Execute**
- Attend to team health
  - Monitor team processes
  - Cue and alert to possible problems
  - Diagnose nature of team problem
  - Reengage “organize for teamwork”

## Taskwork

**Prepare**
- Develop mission plan
  - Analyze mission
  - Identify tasks
  - Allocate tasks
  - Develop schedule
  - Assign resources
  - Identify constraints
  - Develop contingencies

**Execute**
- Execute mission plan
  - Monitor
  - Assess situation
  - Decide on needed plan adjustment
  - Issue directives
  - Execute / develop products
Model 2
Team Planning/Execution Feedback

All processes may be accomplished through an interplay of individual and team work.
Model 3: Individual/Team Interplay

Individual

Notice need for interaction

Prepare for interaction

Decided interaction topic & method

Recommend interaction topic & method

Interact

• Info exchange
• Brainstorm
• Review
• Negotiate
• Consolidate
• Handoff
• Decide and disseminate

Team

Perform Task

• Goal formulation
• Monitoring
• Diagnosis
• Opportunity/problem identification
• Action identification
• Action evaluation
• Action selection

Deliver Product

• Person directed questions & answers
• Shared visualizations
• Shared documents
Model 4
Coupling Cognition, Behavior, and Products

- **Tools** → **Individual Cognitive** → **Understanding needed to do task** → **Individual Behavior** → **Understanding acquired from doing the task** → **Individual Products**

- Other non-cognitive impacts on behavior

- Work required to use tools

- **Team Cognitive** → **Team Behavior** → **Team Products**
Common Ground

• What each collaboration participant assumes about each other in order to have effective interactions

• Includes each team member’s assumptions about other team members’
  - Goals; e.g., where they’re coming from
  - Skills, expertise, and information, to include knowledge about the external situation
  - Status, to include workload, fatigue, distraction, level of engagement
  - Degree of commitment and buy-in
  - Cognitive strategies and approach to problem solving