Developing Shared Understanding through Knowledge Management: Collaboration and Meaning Analysis Process (C-MAP)

Joan R. Rentsch

Organizational Research Laboratory
The University of Tennessee

Office of Naval Research Award: N00014-05-1-0624
Presentation to Collaboration and Knowledge Management Workshop
January 24-26, 2006
Developing Shared Understanding through Knowledge Management: Collaboration and Meaning Analysis Process (C-MAP)

University of Tennessee, Organizational Research Laboratory, Knoxville, TN, 37996

Research Team

Lisa Delise
Lab Manager

TBA: Technical Guru, Graduate Research Assistant
Long Term Goals/Project Objectives

Investigate propositions of the Structural Model of Team Collaboration including the macro-cognitive processes

Examine processes related to knowledge building, knowledge interoperability, and shared understanding
Long Term Goals/Project Objectives

Develop and investigate the Collaborative and Meaning Analysis Process (C-MAP) based on a foundation of team cognition research

Develop process measures of team cognition and collaboration

Develop a scientific basis for building supporting technologies for collaboration and knowledge building
Project Objectives
Initial Experiment

Obtain and establish a laboratory task
Noncombatant Evacuation Operation
(time pressure, cognitive overload, unique roles, heterogeneous knowledge)

Develop the Collaboration & Meaning Analysis Process
(C-MAP)

Develop measures of cognition and meaning sharing
(e.g., knowledge interoperability, shared understanding)

Conduct study
Research Questions: Background

**STRUCTURAL MODEL OF TEAM COLLABORATION**

**Problem Area Characteristics**

- **Collaborative Situation Parameters:**
  - time pressure
  - information/knowledge uncertainty
  - dynamic information
  - large amount of knowledge (cognitive overload)
  - human-agent interface complexity

- **Team Types:**
  - asynchronous
  - distributed
  - culturally diverse
  - heterogeneous knowledge
  - unique roles
  - command structure (hierarchical vs. flat)
  - rotating team members

- **Operational Tasks:**
  - team decision making, COA selection
  - intelligence analysis (team data processing)

**Meta-Cognitive:**
- individual understanding of problem conditions
- individual mental model development of situational significance

**Information Processing:**
- problem identification
- understanding problem task
- establish team communication and trust
- establish data filtering methods
- establish meaning transfer conventions

**Knowledge Building:**
- problem definition
- individual task knowledge
- individual team knowledge

**Communication Mechanism for Information Processing and Knowledge Building (applies to all stages):**
- presenting individual information
- disagreement
- questioning

- discussing individual information
- negotiating perspectives
- discussion of possible solutions

- discussing team generated information
- providing rationale for individual solutions
- agreement

**Collaboration Stages**

- **Team Knowledge Base Construction**
- **Collaborative Team Problem Solving**
- **Team Consensus**
- **Outcome Evaluation and Revision**

**Achieve Goal**

- Yes
- No

- compare problem solution against goals
- analyze, revise output
- goal requirements
- exit criteria

C-MAP is relevant to red items
Research Questions: Background

Team Member Schema Similarity (TMSS)

Team-Related Knowledge

NOT THIS
Research Questions: Background

Team Member Schema Similarity (TMSS)
Team Member Schema Congruence

Donna’s schema
- Professionalism
- Task-oriented

Mitch’s schema
- Speaking one’s mind
- Integrating ideas

Trust
Supporting others

Congruence = A *match* between team members’ schemas in content and/or structure
Team Member Schema Similarity Model

- Membership Influences
- Schema Communications
- Functional Knowledge
- Team Schema Congruence
- High Quality Information
- Enhanced Taskwork
- Enhanced Teamwork
- Team Effectiveness

Rentsch & Hall (1994)
Research Questions: Background

Collaboration & Meaning Analysis Process (C-MAP)

Based on schema communication processes

Externalizing knowing & understanding

Articulation of underlying understanding & meaning formation
Research Questions

Hypotheses were generated based on TMSS research and on the Structural Model of Team Collaboration

Knowledge building, knowledge interoperability, shared understanding related to high team functioning
Research Questions

Hypothesis 1: Teams using the C-MAP will have higher knowledge interoperability than teams not using this process.

Hypothesis 2: Teams using the C-MAP will have more congruent knowledge structures than teams not using this process.
Research Questions

Hypothesis 3: Teams using the C-MAP will have higher levels of performance than teams not using this process.

Hypothesis 4: Knowledge interoperability and congruent knowledge structures will predict team performance.
Initial Experiment

Sample

147 UT college students randomly assigned to 49 teams of 3 members

Task

NEO

- conducted an analysis of the task
- 2 pilot teams to learn about task
Initial Experiment

Intro:
- Overview
- Consent
- Cognitive Ability

ASK: Part I
- Knowledge Recall

Control

ASK: Part II
- Sorting
- Labeling
- Rating

CMAP Intervention:
- Comm Prompts
- Info Board Example
- Interactive Example

Preparation Time

Mission Discussion

Debrief and Payment

Attitudinal Measures:
- Equity
- Satisfaction
- Effectiveness
- Agreement
- CMAP
- Trust
- Viability

Knowledge Interoperability Measure

Joan R. Rentsch, Ph.D.
Initial Experiment

C-MAP Manipulation

• Training
• Role blurb
• Prompts
• Information Board (posted & structured knowledge)
Sample C-MAP Prompts

What do you know that your teammates must know?
TELL WHAT

What do your teammates know that you must know?
ASK WHAT

How are pieces of information related?
TELL CONNECTIONS

How do your teammates believe pieces of information are related?
ASK for CONNECTIONS
C-MAP Interactive Example

John owns a loft at 121 West Street and rents it out for parties and other events.

John just bought an old property at 645 Gay Street for parties and is living in his loft on West Street.

There was a fire last night that destroyed several properties on Gay Street from 590 to 660.

We need to find a new location!!

There is a trance music DJ available that will offer a nice discount to perform at the party.

We can hire This DJ!

The party is an engagement party for Betty and Joe who hate trance music.

The DJ is a good friend of Joe’s and he’s willing to play country music, which is Betty and Joe’s favorite.

We can hire This DJ!
Initial Experiment

Intro:
- Overview
- Consent
- Cognitive Ability

Control

Preparation Time

Mission Discussion

ASK: Part I
Knowledge Recall

ASK: Part II
- Sorting
- Labeling
- Rating

Debrief and Payment

Attitudinal Measures:
- Equity
- Satisfaction
- Effectiveness
- Agreement
- CMAP
- Trust
- Viability

Knowledge Interoperability Measure

CMAP Intervention:
- Comm Prompts
- Info Board Example
- Interactive Example

Organizational Research Laboratory

Joan R. Rentsch, Ph.D.
## ASK: Part I
### Knowledge Recall

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>High tide is from 7am-9am and 8pm-10pm</td>
</tr>
<tr>
<td>6</td>
<td>The CH-53 has a range of 500 miles</td>
</tr>
<tr>
<td>4</td>
<td>It takes a SEAL team 45 minutes to get from the shore to the church</td>
</tr>
<tr>
<td>7</td>
<td>A SEAL team consists of 7 people</td>
</tr>
<tr>
<td>1</td>
<td>Zodiacs have a speed of 15 miles per hour</td>
</tr>
<tr>
<td>10</td>
<td>A SEAL or Army team can parachute from a C-130</td>
</tr>
<tr>
<td>5</td>
<td>The CH-53 cannot fly in fog</td>
</tr>
<tr>
<td>8</td>
<td>The USS Enterprise is 200 miles from the church</td>
</tr>
<tr>
<td>3</td>
<td>High tide is about 2 feet</td>
</tr>
<tr>
<td>9</td>
<td>Helicopters can be heard within 5 miles</td>
</tr>
</tbody>
</table>
High tide is from 7am-9am and 8pm-10pm
The CH-53 has a range of 500 mi
It takes a SEAL team 45 minutes to get from shore to church
Zodiacs have a speed of 15 mph
The CH-53 cannot fly in fog
High tide is about 2 feet
A SEAL team has 7 people
Enterprise is 200 miles from church
ASK: Part II
Sorting and Labeling

Tide travel

Enterprise is 200 miles from church

CH-53 Specs

SEAL team

Enterprise distance

High tide is from 7am-9am and 8pm-10pm.
The CH-53 has a range of 500 mi.
SEALS = 45 minutes shore to church.
Zodiacs have a speed of 15 mph.
The CH-53 cannot fly in fog.
High tide is about 2 feet.
A SEAL team has 7 people.
Enterprise is 200 miles from church.
**ASK: Part II**

**Sorting and Labeling**

- **Tide travel**
  - High tide is from 7am-10pm and 8pm-12am
  - Zodiaks have a speed of 15 mph
  - High tide is about 2 feet

- **SEAL team**
  - A SEAL team has 7 people

- **CH-53 Specs**
  - The CH-53 has a range of 500 miles
  - The CH-53 cannot fly in fog

- **Enterprise distance**
  - Enterprise is 200 miles from church
### ASK: Part II

#### Similarity Ratings

Rate how similar the groups are on a scale from -5 (Very Dissimilar) to +5 (Very Similar)

<table>
<thead>
<tr>
<th></th>
<th>Tide travel</th>
<th>SEAL team</th>
<th>CH-53 Specs</th>
<th>Enterprise Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tide travel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEAL team</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CH-53 Specs</td>
<td>3</td>
<td>-3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enterprise Distance</td>
<td>2</td>
<td>-4</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
Initial Experiment

Measures

Congruent Knowledge Structures - Adaptive Structured Knowledge (ASK) Assessment

Knowledge Interoperability - 75 items (based on task analysis)

Team Process - 2 raters coded 5-minute segments
tell/ask what, tell/ask why, tell/ask agreement,
tell/ask connections

Team Performance - 2 raters scored Final Plans
Initial Experiment

Pilot teams (n = 6)
Refined instructions, technology, C-MAP manipulation

Preliminary Results
Random assignment confirmed
(e.g., no differences between conditions for gender, familiarity, cognitive ability)
Initial Experiment’s Results

Hypothesis 1: Teams using the C-MAP will have higher knowledge interoperability than teams not using this process.
Initial Experiment’s Results

Knowledge Interoperability  \( t = 2.28^* \)
Initial Experiment’s Results

Own Role Knowledge  \( t = 1.99, p = .054 \)

Other Role Knowledge  \( t = 2.06^* \)
Initial Experiment’s Results

Hypothesis 2: Teams using the C-MAP will have more congruent knowledge structures than teams not using this process.
Initial Experiment’s Results

Congruence of Knowledge Structure  \( t = 2.09^* \)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Congruence of Knowledge Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0.74</td>
</tr>
<tr>
<td>C-MAP</td>
<td>0.81</td>
</tr>
</tbody>
</table>
Initial Experiment’s Results

Hypothesis 3: Teams using the C-MAP will have higher levels of performance than teams not using this process.
Initial Experiment’s Results

Transportation Score  $r = .28^*$

![Graph showing transportation scores for Control and C-MAP conditions]
Initial Experiment’s Results

Hypothesis 4: Knowledge interoperability and congruent knowledge structures will predict team performance.

No significant results for congruent knowledge structures

Other Role Knowledge and Transportation Score $r = .30^*$
Initial Experiment’s Results

C-MAP associated with improved Team Process \( t = 2.41^* \)
Initial Experiment’s Results

Ask \quad t = 0.03^* \\
Connections \quad t = 0.01^*
Initial Experiment’s Results

Tell connections  $t = 2.73^*$
Initial Experiment’s Results

![Graph showing frequency of different questions asked and answered under control and C-MAP conditions.]

- Ask What: Higher frequency for C-MAP compared to control.
- Ask Why, Ask Connections, Ask Agreement: Lower frequency compared to Ask What.
Next Project’s Objectives & Approach

Expand lab to 6 networked computers & Ewall interface
Develop experimental stimuli & materials
Conduct a study using distributed teams
Improve measures (process measure), stimuli, & design
Technical Contributions

Adaptive Structured Knowledge (ASK) Tool

The C-MAP can be encoded into technology designed to facilitate team functioning and performance based on the ACE-IT model
C-MAP Contribution to Collaboration Technology

Collaborative behavior was affected by knowledge externalization & prompting, which can be built into support technologies.

Knowledge interoperability was affected by knowledge externalization & prompting, which can be built into support technologies.
C-MAP as scientifically based foundation for building support technology
- Externalization of knowledge structures/schemata
- Prompting transfer and development of knowledge
- Increasing knowledge interoperability
- Increasing shared understanding
- Increasing team member schema similarity
Advanced Cognitive Engineered Intervention Technologies (ACE-IT)

- Collaborative Task
  - Leader Team-Related Schemas
  - Member Team-Related Schemas
  - Collaborative Task Analysis
    - T.E.A.M.
      - Team Enhanced Action Mediators
      - Team Member Schema Similarity
      - Team Performance

Rentsch & Hutchison (1999) Organizational Research Group
Advanced Cognitive Engineered Intervention Technologies (ACE-IT™)

Preliminary pilot test indicates T.E.A.M.s embedded in software improved team performance on a simulated military task

Rentsch & Hutchison (1999) Organizational Research Group
Expected Final Products

C-MAP as a scientifically-based foundation for building support technology

The C-MAP research program will contribute to:

The development of methods for representation and transfer of meaning

The understanding of the processes of team cognition
Potential Impact

Influence the development of support technology

Provide empirically tested, theoretically derived hypotheses to shared understanding research

Contribute methodological innovations

Contribute to the understanding and measurement of the development of congruent knowledge structures and contribute to testing the Structural Model of Team Collaboration
Planned Publications

Expect to present this study at a conference

Expect to prepare a manuscript for submission to journal based on this study

Master’s thesis based, in part, on these data