Evaluating the Performance of Collaboration Engineers

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Abstract

Collaboration Engineering (CE) is an approach to designing collaborative work systems for high-value tasks, and transferring them to practitioners to execute for themselves without support from a collaboration expert. The stakes are high on a CE project, so it would be useful to have a way to evaluate the performance of the collaboration engineers (CEs) who design the work systems. One can evaluate an engineer in terms of the efficiency of resource use, the timeliness of completion, stakeholder satisfaction, and the quality of work with respect to objectives. Measures for resource efficiency, timeliness, and satisfaction are common across disciplines. Measures of work quality, however, are specific to each discipline because each has different objectives. This paper focuses on evaluating the performance of CEs with respect to work quality. Toward that end, we contribute a seven-stage CE methodology based on the Six Layer model of collaboration, and define for each stage its objectives, key activities and work products. From those we derive indicators of work quality for each stage based on a) the justifiability of key decisions; and b) quality of work products. The performance indicators are framed as checklist questions with either yes/no, no/yes, or five-point scales. These indicators are heuristics; they are not designed to be validated metrics for rigorously-defined theoretical constructs, and are not intended to support theoretical and experimental research. They are useful for evaluating of CEs’ performance during and after a project, and also would support further exploratory and engineering research on the performance of CEs.

1. Introduction

Collaboration Engineering (CE) is an approach to designing collaborative work systems for high-value tasks, and transferring them to practitioners to execute for themselves without ongoing support from collaboration experts [26]. When CE first emerged as an academic field, researchers used the Five Ways model [22] to define its research agenda [6, 15]. The Five Ways model proposes five bodies of knowledge that comprise an engineering discipline:

- Ways of thinking: Concepts and theories to inform design and deployment of solutions
- Ways of working: Structured methodologies and techniques for designing, developing, and deploying solutions
- Ways of modeling: Conventions to represent critical aspects of problem- and solutions-spaces
- Ways of controlling: Approaches to measuring and managing engineers and engineering projects
- Ways of supporting: Tools and technologies to support engineers as they design, develop, and deploying solutions

The research CE community has made substantial progress on ways of thinking [4, 8, 23], working [12, 16], modeling [13, 14, 24, 25], and supporting [5, 18]. Some work has also begun on ways of controlling. Santanen, Kolfschoten and Golla [21], for example, developed a CE maturity model with rubrics for assessing the maturity of an organization’s CE processes. Several authors also proposed approaches for measuring the six patterns of collaboration that characterize the ways a group moves through its activities [17, 20]. Such metrics are useful for evaluating and comparing collaboration techniques. Because Collaboration Engineers (CEs) are scarce and expensive, however, and because the stakes are high for tasks upon which they work, it would also be useful to have an approach to evaluating the performance of CEs. This could be useful for multiple purposes, among them: Establishing standards and curricula for professional certification of CEs, informing recruiting and hiring decisions, checking quality gates during CE projects, structuring post-project reviews, performance evaluations for CEs, and planning professional development for CEs.

An engineer’s performance may be evaluated in terms of the justifiability of key decisions an engineer makes in each phase, and of the quality of the work products the engineer creates. We used an applied science/engineering (AS/E) research approach to develop such an approach for CE. The goal of AS/E is to use scientific knowledge and scientific methods to develop generalizable solutions of important classes of unsolved problems in the field [9].

As a first step toward formalizing such an approach to evaluating collaboration engineers, we drew on the Six Layer Model of Collaboration [4] to derive a work breakdown structure for CE projects, which we then elaborated to a seven-stage methodology for CE. We defined for each stage an objective, a set of key activities, and a set of work

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products. From those, we derived a set of performance indicators for CEs for each stage of the methodology based on the justifiability of certain key CE decisions; and on the quality of the work products that CEs produce.

The CE methodology with its stages, objectives, work products, and quality indicators were informed not only by the CE literature, but also the facilitation, process management, Lean, Six Sigma, Business Process Re-engineering, and project management literatures. They were also informed by experiences from each author’s 20+ years in the field designing and deploying collaborative work systems, managing projects, and leading process improvement initiatives. Over that period we designed or redesigned more than 1000 collaborative work processes, took them into the field, and observed the outcomes. Good judgment, it is said, comes from experience, and experience comes from bad judgment. These indicators are, among other things a record of our most embarrassing mistakes.

2. Background

Under certain conditions, users of collaboration technology gain a substantial increase in speed, efficiency, quality of work products, and satisfaction [10, 11, 19], but these gains are typically only realized in groups led by expert facilitators. These facilitators, though, are scarce and expensive, so many groups cannot realize the potential benefits of collaboration technology.

The goal of a CE project is to create an effective, efficient, and satisfying collaborative work system that non-experts can execute for themselves with little or no training, while realizing gains similar to those of groups led by collaboration experts. Drawing concepts from Alter [1] and Rother & Shook [27] we define a work system as: A recurring practice, controlled by someone or something (person, policy, technology or similar control mechanism), in which humans and/or machines take purposeful action using input from suppliers (information, technology, materials and/or other resources) to produce specific outputs (products, services, information or similar work products) to create value for identified stakeholders.

The Six Layer Model of Collaboration considers collaborative work systems at six different levels of abstraction [4]. Table 1 summarizes the focus of each layer. The model provides an organizing structure for many of the hundreds of concepts, phenomena, constructs, theories, metrics, modeling conventions, techniques, best practices, and design considerations pertaining to collaborative work systems.

A CE must make hundreds of success-critical design choices when creating a collaborative work system for others to operate. Using the six layer model, the CE can make those choices one layer at a time, and so reduce cognitive load. If a designer gives insufficient attention to design concerns at any layer of the model, the new work system risks failure in the field. The model and the concepts it organizes therefore serves as a completeness-check for designers to assure that critical issues have been considered and settled.

There are dependencies between adjacent layers in the model, so design choices at one layer may necessitate design changes in the layers above or

<table>
<thead>
<tr>
<th>Layer</th>
<th>Content</th>
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</thead>
<tbody>
<tr>
<td>Collaboration Goals</td>
<td>Concerns group goals (desired states or outcomes), private goals, and goal congruence – the degree to which individuals believe that working toward group goals will help one attain private goals.</td>
</tr>
<tr>
<td>Group Deliverables</td>
<td>Concerns goods or services a group produces to achieve its goals. Deliverables may be tangible or intangible, but it must be verifiable that they meet predetermined standards for completion.</td>
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<tr>
<td>Group Activities</td>
<td>Concerns the set of work packages by which a group will create its deliverables (What the group will do, but not how it will do it).</td>
</tr>
<tr>
<td>Group Procedures</td>
<td>Concerns tactics a group uses to move through its activities. Includes: a) collaboration patterns that characterize how a group moves through its activities; and b) collaboration techniques it uses to invoke desired variations of those collaboration patterns.</td>
</tr>
<tr>
<td>Collaboration Tools</td>
<td>Concerns technical (e.g. software, paper, whiteboard) and non-technical (e.g. checklists, forms) capabilities a group uses to focus its thinking and instantiate its collaboration techniques.</td>
</tr>
<tr>
<td>Collaboration Behaviors</td>
<td>Concerns the things people say and do with their tools as they collaborate. Considers support for and constraints on observable actions of people making joint effort toward a group goal.</td>
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below. For example, if a group’s goals were to change (Layer 1), they would probably have to change the deliverables they would create to achieve the new goals. As the deliverables were changed, it is likely that the group’s activities would have to change to create these new deliverables. The six-layer model provides a mental tool for tracing the implications of design changes in an orderly way from layer to layer.

The strongest dependencies among the layers are all in the same direction: design choices on a given layer are heavily constrained by design choices in the layer above. There are also, however dependencies in the other direction, but they are fewer and less constraining. For example a group could not use a procedure that required a collaboration tool to which the group did not have access. Nonetheless, a given procedure may be implemented with a wide variety of tools (e.g. paper; web conferencing system; group support system). The predominance of dependencies is in one direction, however, the model suggests general guideline for an efficient order for making design choices: consider first the concerns in the Goals Layer at the top of the model, and work down to the Behaviors layer at the bottom. This insight would inform the development of structured CE methodologies in general, and it informed the work breakdown structure for CE projects that we contribute to here. The first five phases of the CE Methodology pertain directly to the layers of this model and are sequenced in accord with the strongest dependencies among the layers. The last two phases pertain instead to change management and continuous improvement respectively.

Collaborative work systems are designed and deployed to improve the value an organization derives from its processes. In this paper, we call the specific organizational process for which a given collaborative work system will be built a “task.” Examples of tasks (as we use the term here) would be internal audit, software requirements negotiation, and proposal development.

3. Methodology for CE

Seven work packages characterize the stages in our work breakdown structure for CE projects (Table 2). Each is a stage in the CE Methodology. We outline the project methodology below by defining the objective, key activities, work products, and a set of quality indicators for each stage. In this paper, we format the quality indicators as checklist questions that may be used by CEs for self-evaluation during each stage of a CE project, and may be used to evaluate the performance of CEs after a stage or project. All but a handful of the quality indicators in this format use either a yes-no scale, where a yes indicates high quality, or a 1-to-5 scale, where 1 indicates low quality and 5 indicates high quality. To aggregate scores across all items, we assign a value of 1 to a “yes” or “no” answer that indicates low quality, and a score of 5 to “yes” or “no” answers that indicate high quality.

All items for a given phase are aggregated into an Index score. A CE opportunity with a higher aggregated score would be regarded as better quality than an opportunity with a lower score EXCEPT where there is a Stop score, which would indicate a compelling reason for not to pursue an opportunity, regardless of the Index score. Opportunities with the highest Index scores and no Stop scores would be prioritized at the top of a list of prospective projects; any opportunity with one or more Stop scores would be omitted from further consideration.

CE projects are complex, involving hundreds of decisions and design elements. There are, therefore, numerous indicators of work quality for CEs. Although the indicators are many, we developed a simple scoring approach to manage and aggregate the results. The aggregation and management of work quality scores never became a practical challenge in the field.

Stage 1. Choose CE Opportunities.

Stage 1 pertains to the Goals Layer of the Six Layer Model. Its objective is to decide which CE projects to undertake. Collaboration is expensive, so CEs should only initiate projects with the potential to create substantial value. CE projects are also expensive, and so should only be undertaken where there is a high probability of success. The key activity of this stage is: Assess and prioritize CE opportunities. The work product for this activity is:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Work Package</th>
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<tbody>
<tr>
<td>1</td>
<td>Choose CE Opportunities</td>
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<tr>
<td>2</td>
<td>Define Goals and Strategies for the Collaborative Work System</td>
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<tr>
<td>3</td>
<td>Create a Work Breakdown Structure for the Collaborative Work System</td>
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<td>4</td>
<td>Design Procedures for Work Packages</td>
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<tr>
<td>5</td>
<td>Develop the Collaboration System</td>
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<tr>
<td>6</td>
<td>Deploy the Collaborative Work System</td>
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<tr>
<td>7</td>
<td>Improve the Collaborative Work System</td>
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</table>

a no-yes scale where a no indicates low quality and a yes indicates high-quality, or a 1-to-5 scale, where 1 indicates low quality and 5 indicates high quality. To aggregate scores across all items, we assign a value of 1 to a “yes” or “no” answer that indicates low quality, and a score of 5 to “yes” or “no” answers that indicate high quality.

<table>
<thead>
<tr>
<th>Table 2. Methodology for CE Projects.</th>
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<td>Stage</td>
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</table>

a prioritized set of CE opportunities with rational for the rankings.
We adapted the checklist of quality indicators for this activity from [7] who derived them from the Value Frequency Model for Willingness to Change, and tested them in a two year field study. We adapted that work into a Collaboration Opportunity Assessment Scoring Sheet that a CE can use when to decide whether a project should go forward. The Collaboration Opportunity instrument includes five sets of questions to which a CE should seek answers before deciding whether to pursue an opportunity.

Each set starts with a general item about the assessment category as a whole, followed by several more-specific questions to probe for specific pitfalls. Six items for this stage are preceded by an asterisk, and displayed in italics. This identifies them as breaker-questions. A score of 1 on a breaker questions is called a *Stop score*. A Stop score indicates a high risk that a CE project will fail, regardless of scores on all other items.

Moving forward on a project with high scores and no breakers would indicate high performance for a CE. Moving forward with low scores or breakers would indicate low performance.

The quality indicators that comprise the Collaboration Opportunity Assessment are:

**A. Levels of Collaboration**
Assessment of the need for collaboration
1. Is the task collaborative? (n/y)?
2. *Must the task be executed by group making joint effort (n/y)?
3. Is it difficult or impossible for a talented individual to do the task alone? (n/y)
4. Does the work required concerted effort? (n/y) (See “Interdependence of Effort” in Table 3)
5. Does the work require coordinated effort? (n/y) (See “Interdependence of effort” in Table 3)

**B. Organizational Value-Add**
Value of executing the task
6. *How important is it to the organization, that this task be executed well? (1-5)
7. What level of benefit would the organization get if the task were well executed? (1-5)
8. How high is the risk to the organization if task is executed poorly? (1-5)
9. *What level of satisfaction do stakeholders feel toward the way the task is currently done? (1=high satisfaction; 5=low satisfaction)
10. What level of satisfaction do participants feel toward the current deliverables of the task? (1-5)
11. What level of satisfaction do people who use the task deliverables feel toward them? (1-5)

**C. Size and Scale of Task**
How often (frequent) is the task done? (1-5)

*How frequently does a typical individual leader (practitioner) lead the execution of the task? (1-5)

How long does it take to complete the task (Cycle time of one iteration of the task) vs. what stakeholders deem to be optimal? (1 = close to optimal; 5 = far from optimal)

**D. Leadership and responsibility**
Assessment of the responsibilities for the task and workflow.
20. Are specific individuals (Practitioners) leading the execution this task frequently? (n/y)
21. Is there a process owner (manager, key employee or similar) that is responsible and accountable for successful execution of the task? (n/y)

**E. Prior Efforts**
Assessment of critical practical knowledge about the task issues and budgets
22. Have there been prior attempts to change the process that failed? (y/n)
23. *If there were issues that blocked past attempts to change the process, how much negative impact might those issues have on the acceptance of a CE solution? (1= large impact; 5 = small impact)

**F. Change Readiness**
26. How willing would task participants be to perform the task in a different way using a revised process? (1-5)
27. How willing would task participants be to use different technology for this task? (1-5)
28. Are there success-critical stakeholders who would suffer from a change to the process? (y/n)
29. *Is there a success-critical stakeholder who would block any significant change to the current work system? (y/n)
30. Are there success-critical stakeholders who would resist using a new or different technology to support the process (y/n)
31. Would there be tangible benefits to the individuals who participate in the process if it were improved? (n/y)

Stage 2. Define Goals and Strategies for the Collaborative Work System

This stage pertains to the Goals and Deliverables layers of the Six Layer model, along with some project management issues. The objectives of this stage are: a) to engage the key players in the design process; b) to understand the goals of the work system to be developed; c) to specify task deliverables; d) to analyze stakeholder roles, skills, & interests; and e) to assess resource requirements for the new work system.

For this stage, we specified separate work products and separate quality indicators for each key activity. The four key activities for this stage are:

A. Identify and engage success-critical stakeholders.

The work product for this activity is a list of success-critical stakeholders elaborated with contact information and written commitments to join the project. Stakeholders are deemed to be success-critical if they have the power to thwart the project if their interests are not accommodated [3]. Quality indicators for the stakeholder list are:
1. Are the involved stakeholders success-critical? (n/y);
2. Are all success-critical stakeholders engaged? (y/n);
3. How well does stakeholders or their representatives meet the so-called CRACK criteria? (1-5) (Table 4).

B. Negotiate task goals.

This activity has four work products:
• Task Goal Statement defines states or outcomes to be maintained or improved by executing the task. The task goal for an Internal Audit, for example, might be, “Smaller losses from failed internal processes, people and systems.” Quality Indicators for task goal statements are:
4. Task goals expressed as states or outcomes, not as actions or deliverables (n/y).
5. Task goals meet SMART criteria (specific, measurable, achievable, relevant, time bound) (n/y).
6. Success critical stakeholders agree to task goals. (n/y)

Table 4. CRACK Criteria for Stakeholders in a CE Project

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Committed</td>
<td>Feels obligated to stay with the project through completion</td>
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<tr>
<td>Representative</td>
<td>Shares vested interests of his/her constituents</td>
</tr>
<tr>
<td>Authorized</td>
<td>Leaders accept and enforce this stakeholder’s commitments</td>
</tr>
<tr>
<td>Collaborative</td>
<td>Will to seek win-win solutions</td>
</tr>
<tr>
<td>Knowledgeable</td>
<td>Understands issues and solutions</td>
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</table>

• Background information, e.g. key events, task relevance, limitations and constraints, past experiences with task, and other important information. Quality indicators for background information are:
7. Completeness (1-5)
8. Clarity (1-5).

• Issues, e.g. information about current or past problems with the task, their root causes, earlier attempts to improve the workflow, the symptoms of the problems, opportunities for improvements, and barriers to goal attainment. Quality indicators are:
9. Completeness (1-5)
10. Clarity (1-5).

• Value, e.g. the value of the task for the intended stakeholders, what stakeholder interests are served by this task. Quality indicators for value are:
11. Have all the relevant interests of all success-critical stakeholders been discovered and shared? (n/y)
12. Have key stakeholders committed to mutually acceptable agreements about which of their interests should and should not be accommodated by the new work system? (n/y)

C. Negotiate specifications for task deliverables.

The work product for this activity is: a list of task deliverables specifying contents and output formats. This includes output structure, length/size, delivery medium, language, measures of merit (quality level, ambition level), destinations and uses (to whom will deliverables be delivered, and for what will they be used), and timings (e.g. frequency, deadlines). Quality Indicators are:
13. Completeness of deliverable specifications (1-5)
14. Success critical stakeholders have agreed to deliverable specifications (y/n).

D. Determine operational resource requirements for operating the work system.

The work product for this activity is: a resource specification listing the required human resources,
their roles/responsibilities, economic resources, and other resources or assets required to operate the work system. Quality Indicators are:
15. Are the resource estimates backed by data and reasoning? (1-5)
16. Have all resource requirements been identified? (1-5)
17. Have all unnecessary resources been eliminated? (1-5)

Stage 3. Create a Work Breakdown Structure for the Collaborative Work System
The objective of this stage is to design a work process for the task that will produce the specified deliverables.
This stage corresponds to the Activities layer of the Six Layer Model. It has two key activities:
A. Decompose a task into work packages.
The work products for this activity are: A list of named work packages, each elaborated with output specs, input specs, and the roles who should participate. Quality Indicators for work packages are:
1. Does the work package name begin with a strong, specific action verbs and reference specific data sets, e.g. “Identify potential risks”? (n/y)
2. Do specifications indicate the requisite structures of the work package inputs and outputs e.g. set, list, tree graph? (n/y)
3. Have success-critical stakeholders agreed to work package specifications? (n/y) Is the list of roles that must participate in each work package complete and parsimonious? (n/y)
B. Develop conditional logic for order of execution of work packages.
The work product for this activity is: A model of the conditional logic for order of execution of work products, e.g. a workflow diagram.
Quality Indicators for this model are:
4. Would executing work packages according to the conditional logic produce specified task deliverables? (n/y)
5. Efficiency (economic, political, social, cognitive, temporal, emotional, physical) (1-5)
6. Simplicity, clarity, learnability (1-5)
7. Accommodates requisite variety? (n/y)
8. Output-input continuity of sequential work packages? (n/y)

Stage 4. Design Procedures for Work Packages
The objective of this stage is to optimize the quality of Task Deliverables across the economic, political, social, cognitive, temporal, emotional, and physical constraints on conducting it.
This stage addresses concerns pertaining to the Procedures Layer of the Six Layer Model. Three key activities comprise this stage:
A. Map collaboration patterns for each work package.
CE researchers discovered six patterns of collaboration that characterize the ways groups move though their activities (Table 5). The work product for this activity is: a conceptual design for each work package, specified as a sequence of collaboration patterns and the conditional logic for their order of execution. Quality indicators for the conceptual designs are:
1. The conceptual design will produce work package outputs? (n/y)
2. Notations include name and data set for each collaboration pattern? (n/y)
3. The conceptual design achieves efficiencies (e.g. economic, political, social, cognitive, temporal, emotional, physical)? (1-5)
4. The design is as simple as possible, clear and learnable? (n/y)
5. Does the design accommodate the variety of conditions under which the task must be executed? (n/y)
6. There is output-input continuity of all work packages? (n/y)
B. Select collaboration modes for each collaboration pattern (Table 4).
The work product for this activity is: a conceptual design for each work package with collaboration modes specified for each collaboration pattern. The quality indicators for this design is:
7. To what level does the work mode choices optimize the quality of work products over cost, travel time, person hours, cognitive load, motivation, and satisfaction constraints? (1-5)
C. Choose or invent collaboration techniques.
A collaboration technique as a named, scripted practice that produces known variations on the six patterns of collaboration [5]. Some idea generation techniques, for example, push a group for breadth and variety, while others push for speed and quality, others for creativity, and still others for depth and detail [14].
The work product for this activity is: a set of logical designs for work packages elaborated with collaboration techniques for invoking desired variations on each collaboration pattern, and the conditional logic for their order of execution. Indicators of quality for this design are:
8. The techniques invoke desired variation of collaboration pattern(s)? (n/y)
9. Is the technique difficult to execute? (y/n)

1 Requisite Variety pertains to whether a system is sufficiently flexible to accommodate the variety of conditions under which it must operate. For example, a work system that can accommodate only 20 participants would fail if it were often necessary to engage 100 people to complete the task.
10. Is the technique within the capabilities of target practitioners? (n/y)
11. Will executing the selected techniques following the prescribed conditional logic produce the work package outputs? (n/y)
12. Can techniques be executed in the time available? (n/y)
13. Does the structure, content, and format of each technique match the requirements for the inputs of the subsequent techniques? (n/y)

Stage 5. Develop the Collaboration System
The objective of this stage is to create a collaborative work system that non-experts can run successfully with little or no training. This stage addresses the Tools layer and some of the concerns at the Behaviors layer of the Six Layer model. Four key activities comprise this stage:

A. Select and configure tools.
   Every collaboration technique requires the use of some set of capabilities. A classic brainstorming session, for example, requires a) an audio channel to which all participants can listen and contribute, and b) a public list that all participants can see and to which a moderator can add ideas. CEs must select the tools that will provide practitioners with the capabilities they require for the techniques they will execute, and where possible, must configure the tools to restrict counter-productive actions that the group does not want to take (e.g. restrict accidental deleting of ideas during brainstorming) and support the productive actions the groups do want to take (e.g. support simultaneous contribution of ideas to a digital list). The work products for this activity are:
   • A physical design specifying tools and configurations to support each technique.
   • Fully configured tools to support practitioner actions.
   Quality indicators are:
   1. Do the tools and configurations support the actions participants must take and the constraints under which they must act to instantiate the technique? (n/y)
   2. Where possible, do the tools and configurations restrict counterproductive actions? (n/y)
2. What is the level of learnability by the practitioners? (1-5)
3. How easy is it to execute? (1-5)
4. What is the usability level? (1-5)

B. Design transitions between techniques.
When a group finishes one technique, it is sometimes necessary to make changes of data formats, personnel, information availability, technology configuration, and/or the physical environment before the next can begin. To make it possible for non-experts to run a work system, a CE must design and optimize the transition procedures [14]. The work product for this activity is: a physical design elaborated with transition procedures. Quality indicators are:

C. Document the collaborative work system.
Where possible, CEs use appropriate configurations of technology to restrict counterproductive actions and to support productive actions so untrained participants can execute the task with minimal training. However, groups may still require some expert guidance on what they should and should not do with the provided capabilities to achieve their goals. Some collaboration technology lets CEs embed information in the form of text and multimedia documentation in and around the capabilities to provide that guidance [13]. Lacking that, the CE must resort to documents or other means to communicate directions to participants. Work products for this activity are:
   • A fully configured collaborative work system with documentation that includes:
   • Internal documentation – text and multimedia guidance embedded in the technology tools which

<table>
<thead>
<tr>
<th>Table 5. Six Patterns of Collaboration that characterize the ways groups move through their activities. [Adapted from 26]</th>
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<tbody>
<tr>
<td><strong>Pattern</strong></td>
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<tr>
<td>Generate</td>
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<tr>
<td>Reduce</td>
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<td>Clarify</td>
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<td>Organize</td>
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<td>Evaluate</td>
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<td>Build Commitment</td>
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6. What is the speed level by which transitions are done? (1-5)
7. How simple are they? (1-5)
the group will use, (e.g. column headings, voting criteria, participant and leader instructions, and just-in-time learning tutorials).

- External documentation not imbedded in the technology tools the group will use to plan, prepare, execute and follow-up on in the work system (e.g. quick start guides, training materials, leader manuals, participant/user manuals, presentation slides, cue cards, and scripts for people involved in the execution).

Quality indicators are:
10. Is there sufficient guidance embedded in the technology and/or available in separate documents for task leader(s) to plan, prepare, execute and follow-up on the task well? (n/y)
11. Is there sufficient guidance embedded in the technology and/or available in separate documents for participants in the task to prepare and participate effectively and efficiently? (y/n)
12. To what level are the information cues specific and difficult to misinterpret? (1-5)
13. Can the participant respond accurately to the given directions? (n/y)
14. Do participants have easy access to guidance in useful amounts in useful levels of detail? (n/y)
15. Does the process move participants through steps appropriate to the work package? (n/y)
16. Are actions required for transitions minimized? (n/y)
17. Does the process accommodate and support stakeholder’s vested interests? (n/y)
18. Is minimal time required to gain competence in executing the task? (n/y)
19. Is there a need for separate training to learn the work system? (y/n)
20. If separate training is necessary, how much time is necessary for the leaders and for the participants to learn the work system well enough to use it as intended? (1-5)
21. If training in work system is necessary, have the training program and materials been developed and is the training ready to be deployed? (n/y)
22. Do pilot participants produce high quality task deliverables in a timely fashion? (n/y)
23. Do all success-critical stakeholders have positive feelings toward the work system? (n/y)
24. Do pilot participants encourage others to adopt and use the work system? (n/y)

Stage 6. Deploy the Collaborative Work System

The objective of this stage is to **create a self-sustaining and growing community of practice around the work system**. The activities of this stage are not different from those common to innovation or improvement efforts of all kinds [28] [29]. In this paper we therefore enumerate, but do not elaborate on the activities of this stage:

- Plan the change and communication process
- Update the standard operating procedures for the organizational processes
- Install, test and give users access to new technologies
- Train the trainers
- Train the practitioners
- Execute the change and communication plan
- Release the work system
- Track results (Qualitative and quantitative)

Quality indicators for this stage are:
1. Knowledge, interest and ‘intention to try’ levels amongst target group stakeholders (share %)
2. Rate of task success rate (Successes / total attempts)
3. Number of uses of the new collaborative work system (count)
4. Number of people using the work system (count)
5. Number of organizational units using the work system (Count)
6. User ratings of the work system (1-5)
7. Number of requests for enhancements to the work system (count)
8. Participant satisfaction (1-5)
9. Process cycle times and labor hours (count)
10. Knowledge and experience sharing level (communication instances and document availability counts)

Stage 7. Improve the Collaborative Work System

The objective of this stage is to **optimize a collaborative work system in response to new insights and changing conditions**. The activities of this stage are likewise common to most innovation and improvement approaches, so we enumerate but do not elaborate on them:

- Conduct after-action reviews with practitioners
- Evaluate performance of the work system
- Design, implement and test improvements
- Plan roll-out of the updated version
- Release the new version

Quality Indicators for this stage include:
1. Sustained and growing community of practice around the new work system (count)
2. Quality Indicators from the previous stage.

4. Discussion and Conclusions

The indicators presented here have been useful in the field during and after collaboration engineering project for evaluating the performance of CEs in terms of the justifiability of certain key decisions and the quality of their work products. As useful as they have been, however, there is still much research to be done. The scoring approach for the indicators, for example, is still rudimentary. The current Index score provides only ordinal data. Except for the Stop scores, all indicators are given equal weight when they are aggregated. However, experience in the
field suggests they may represent widely divergent levels of risk, some major, some minor, and some moderate. This lack of nuance limits the inferences one can draw by comparing Index scores. It might be reasonable, for example, to infer that CEs with higher Index scores may be performing better than CEs with lower Index scores. With only ordinal data, however, one could not infer how much better one is performing than the other. A more reliable alternative might be a count of high item scores. One might be justified to conclude that CEs with a greater number of high indicators were, at a minimum, more attentive to detail than one with a greater number of low indicators. This approach, however, has not yet been tested in the field. More exploratory research will be required to develop and test aggregation approaches that provide a reasonable approximation of interval-data, which could, in turn, support more nuanced, possibly standards-based evaluations of CEs performance.

Further, the current indicators are heuristics, developed as solutions to a class of practical problems in the field. They were designed to be used quickly, frequently and on the fly by CEs to assess their own performance during a project and for post-project performance reviews. They are not yet validated measures for rigorously defined constructs to support theoretical and experimental research. Each heuristic, however, may be related to one or more constructs relevant to the performance of CEs, and success of CE projects. It is not yet clear, however, what these underlying constructs may be. Further exploratory research will therefore be required to discover and describe these phenomena, how they correlate, the contexts and conditions under which they manifest, and to derive validated metrics for those constructs. This, in turn would facilitate theoretical research to predict and explain observed variations in those constructs, and experimental research will be needed to test those theories. Such theories may, in turn, inform more sophisticated collaboration engineering methods and more precise ways to measure the performance of CEs.

Although the current performance indicators are useful, they are incomplete, in that they focus on quality, which is an important component of performance evaluation, but do not yet focus on efficiency, another important component. Additional exploratory and AS/E research will be required to develop useful indicators of CE efficiency.

Finally, the seven stages of the CE methodology itself, along with their objectives, key activities, work products, and quality indicators has also been useful in the field to support numerous CE initiatives for commercial, non-profit, military, government, and academic organizations. It has also become a useful foundation for educating new CEs. Over the past 6 years, universities in the U.S.A, Germany, and the Netherlands have offered undergraduate and graduate courses that incorporate these concepts. The concepts are also at the heart of a pilot project to develop training for professional certification of CEs. Research to improve the heuristics and to develop validated measures for their underlying constructs may therefore be useful not only for improving performance assessments for CEs, but also for advancing collaboration engineering as profession.

Citations


[27] Rother, Michael and Shook, John, "Learning to see: Value –stream mapping to create value and eliminate MUDA", Cambridge, MA: The Lean Enterprise Institute, 2003.

