Field quality metrics – findings and recommendations

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Abstract

Purpose – Based on a 2015 research survey by the author, the purpose of this paper is to evaluate a group of tablet- and smartphone-based software in order to recommend which one (or two) best matches the requirements for building construction field quality management. The secondary purpose of the paper is to identify which usage criteria best represent the needs of designers and builders. A tertiary but equally important purpose is to identify best means for knowledge transfer to up to 100 project teams per year.

Design/methodology/approach – Using a previously developed in-house questionnaire comprising 34 evaluation criteria, the author identified and evaluated eight currently available field quality management software being used by project teams in several different branches of the author's building construction company. Evaluation involved face-to-face meetings with each of the 11 project teams using a standard questionnaire. Software vendors were also interviewed. Each comment made during interviews was captured and the results were communicated back to the team members for review – there were several comments and clarifications received in this manner. Questionnaires were evaluated, findings and recommendations drafted and circulated to senior management for review.

Findings – Out of the original 34 evaluation criteria, there emerged 12 field-derived evaluation criteria; an additional five arose from the site office, for a total of 17 out of the original 34. While site office-based personnel were comfortable with tablet-based software solutions, field staff such as superintendents favored smartphone-based solutions. Where field staff were required to use tablets for field quality management, they insisted on being accompanied by junior project management staff to act as scribes – all agreed this was inefficient.

Research limitations/implications – The eight software products selected for evaluation were limited to those already in use in the company; in one case a product was evaluated due to strong recommendations from staff based on hearsay. There are many more field quality management software and the field is changing rapidly, however the author believes the findings are of value in analyzing any current or future offering.

Practical implications – The ideal building construction field staff member should be equipped with a tablet used periodically during the workday to access the most up-to-date project documents. But the same individual should use a smartphone for the large majority of quality management observations, such as identifying and tracking to resolution deficiencies and non-conformances. Details of this mix and usage have not been previously identified.

Originality/value – In addition to evaluating a variety of field quality management software and identifying selection criteria, the paper identifies a practical implementation protocol that will maximize the likelihood of successful implementation.

Keywords Computer software, Quality improvement, Quality assurance, Quality management, Quality systems

Paper type Research paper

Introduction

For the first time since the advent of computers, tablets and smartphones, some field quality management software actually makes the day-to-day job of project staff easier, both in the field and in the field office. Issue capture and management, data collection, knowledge and records management have been automated to the point where it is clearly easier for field management staff to use some applications for day-to-day work than their more traditional approaches, such as log books, unconnected cameras (meaning a digital camera that is not directly connected to a quality management database, requiring transcribing of such photos) or memory. Rather than collecting data, then returning to an office to spend time reporting

Change in a construction company requires extensive consultation, especially change in the field. During the course of the research for this report, meaningful content was received from the many company staff in branches actively researching field quality management software.

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about the execution of their work, they now have available convenient, simple tools that support their work while automating issue management and recording. This paper addresses that new reality.

Background

In early October of 2015, the author undertook to survey the various software currently being used for field quality management (defined here as the active identification, notification and resolution of quality issues arising in the field) in the construction company employing him, evaluate it and recommend one or two applications to optimize the field quality management experience. This request was based upon the experience of developing and implementing a monitored construction quality management program for an active project base of 100-150 concurrent projects. It was agreed that more active quality management during construction was a logical next step.

The author was also asked to identify the cost of inattention to quality, which was called the "quality opportunity cost" (QOC). A separate but concurrent review of more than 300 construction projects completed over five years was completed in the same time frame. The QOC study was very limited in the data that could be analyzed, as the company had not historically tracked the costs of inattention to quality – common in the industry. However, one data set was susceptible to evaluation. Overhead costs incurred substantially after project completion were relatively easy to measure. These are at least an indirect measure of the cost of inattention to quality; they include extensions to staff time, rental equipment and facilities, extensions to bonds and insurance, etc.

A study of over 300 projects found that the average QOC equated to 0.95 percent of the average total project cost, several million dollars per year. The result is considered statistically accurate for two reasons: the 300+ projects evaluated represent more than 70 percent of all projects completed during the five-year period; and the original sample was 250 projects, but data for an additional 50 were "found" near the end of the project. The added 50 projects, an increase of 20 percent to the original sample size, impacted the QOC result by a statistically inconsequential 0.01 percent. QOC has been summarized as "1 percent of the cost of construction." This is actually a very conservative measure as it excludes the costs of inattention to quality incurred during the course of a project and not separately identified. Theses costs are estimated at 5 percent or more of the total cost of construction (Moore, 2012).

Methodology

Six of 11 of the company's regional offices were identified as using eight different types of software for field quality management – two offices were in the USA and four in Canada. In total, 11 project teams were identified as actively using newer technology and these were interviewed by the author together with the offices' regional quality managers (RQMs). Input was captured into a pre-existing questionnaire, which had previously identified 34 mandatory and advisory criteria for quality management software selection shown in Table I.

Findings

Interviews and field observations revealed two primary ways that field staff, primarily construction superintendents, engaged with field quality management software:

(1) Construction documents on many sites were already often uploaded to an application that hyperlinks construction documents such as drawings and specifications together with submittals, requests for information and similar active documentation. These documents were periodically accessed in the field, using tablets. Some field staff carry these tablets, often storing them in the surveyor pocket at the back of their safety vest. The use of this document management application appears effective based on a high degree of usage.

No.	
	General
1	Software cost effective
2	Software must be compatible with iPad and/or Windows enabled tablets/computers
3	Software must be web enabled
4	Software must be easily used with simple training available
5	Data must be able to be stored in a secure, web accessible location
6	Data must be backed up frequently and regularly
7	Data from the field must be synchronized with the master/office copy
8	Records must be available for easy archiving
9	Includes links to approved forms in Ops Manual
10	Supports print out and fill in by hand
11	Photos are easily captured and attached to individual items
12	Data are easily accessible to non-project Ledcor staff
13	Ledcor user can see all assignments, due dates, etc.
14	Ledcor user can set different permission levels for different projects
15	Ledcor user can integrate records from other software
16	Includes diary/daily report function suitable for field or office use
17	Reminder of overdue items
18	Content lockable after issuance
19	Items assignable by location
20	Allows task assignments arising from meetings, with assignee, due date, progress details and closure
	Quality checklist management
21	Supports identification and scheduling of reviews
22	Distributes and stores multiple checklists
	Non-conformance management
23	Allows for root cause identification
24	Non-conformances identifiable as to source (consultant, owner, contractor, etc.)
25	Reports sortable by trade
26	Reports easily distributed to stakeholders
27	Resolution easily recorded, distributed and closed items archived
	Other
	Deficiency management
28	Deficiency due date, initial completion, final acceptance notification are automated
29	Deficiency statistics can be easily generated across a number of categories
30	Deficiency reports sortable by trade
31	Deficiency reports easily distributed to stakeholders
32	Deficiency resolution easily recorded, distributed and closed items archived
33	Deficiencies are recordable on drawings
34	Items transform easily into lessons learned

Table I.
Original quality management evaluation criteria

(2) Most transitory issues, deficiencies, non-conformances, etc., are identified and resolved in the field from smartphones, primarily using conventional e-mail and phone calls. Superintendents noted that managing the myriad details of field operations on tablets was too time consuming and awkward based on the tablets and software they had been exposed to.

(3) The company's health and safety management had also been experimenting recently with mobile software called "K2," and concluded from trials that smartphone-based apps were more engaging solutions for the reporting by their field staff, whether part time or dedicated safety officers, or superintendents.

Other operations staff in the field, including project managers and project coordinators/engineers (PCEs), noted that when superintendents were asked to use tablets for field quality management such as punch lists, they either engaged PCEs to accompany them and act as "scribes," doubling the effort investment, or reverted to some combination of

disorganized e-mail[1], written notes or memory. Both the scribe approach and the silo'd notes approach have been identified as inefficient and undesirable for issue or knowledge management (Tan *et al.*, 2010). It appeared that, in order to fully engage superintendents in field quality management, a smartphone-based approach was required.

Eight software applications were identified by project teams, seven in active use and the eighth recently requested by three additional project teams. These software applications can be considered in three basic categories:

(1) Hardware-specific applications do not have a web browser component other than to download the software "app" to a tablet or smartphone. These apps do not create a database external to the hardware device, nor do they permit replication of learned data such as typical deficiency lists, names of staff or subcontractors, etc. This category was dismissed because of these basic shortcomings. This category might suffice for a very small construction company or the individual professional, but becomes ineffective for larger organizations.

(2) Tablet-based applications, of which five were reviewed, are sometimes designed on the desktop, with an accompanying tablet-based app. Others are designed primarily for tablet usage, with a desktop accompaniment. This distinction is important. In the case of desktop-designed applications, the design approach generally resulted in a desire to accommodate too much data on the tablet screen, resulting in a confusing, overly complex interface not favored by field staff. Applications designed for the tablet but including a desktop accompaniment were slightly easier to use in the field.

(3) Smartphone-based applications, of which two were reviewed, are designed primarily for the smartphone interface, but include a desktop accompaniment. In one of the two applications we reviewed, the desktop accompaniment was too weak for effective use in the site office; however, the vendor heeded our suggestions and improved the desktop accompaniment so that it could be used effectively by site office staff and became a recommended application.

In addition to these three basic software types, we identified two basic approaches to data capture:

(1) Graphic-based data capture applications such as shown in Figure 1 require uploading drawings in an electronic format such as PDF or PNG. These typically work on tablets, as the smartphone screen is currently too small for effective use. "Standard" lists of issues such as typical deficiencies and non-conformances are associated with the electronic drawings and the drawings are annotated by tapping or dragging and dropping a specific issue type to a specific location on the drawing.

(2) Text-based data capture applications such as shown in Figure 2 work from lists of rooms, suites, floors and buildings, using these to identify the location of issues.

After reviews and field trials, 17 of the original 34 criteria were identified as critical to proper functionality, as per Table II.

Composite recommendation

Remembering the two basic ways that field staff engage with construction documentation and findings in the field, the recommended solution was to use two different software applications:

(1) Field-based quality document management using tablets with a graphic-based interface. This approach hyperlinks drawings, specifications, requests for information, submittals, etc. such that it is easy in the field to find all current data pertaining to an area of construction.

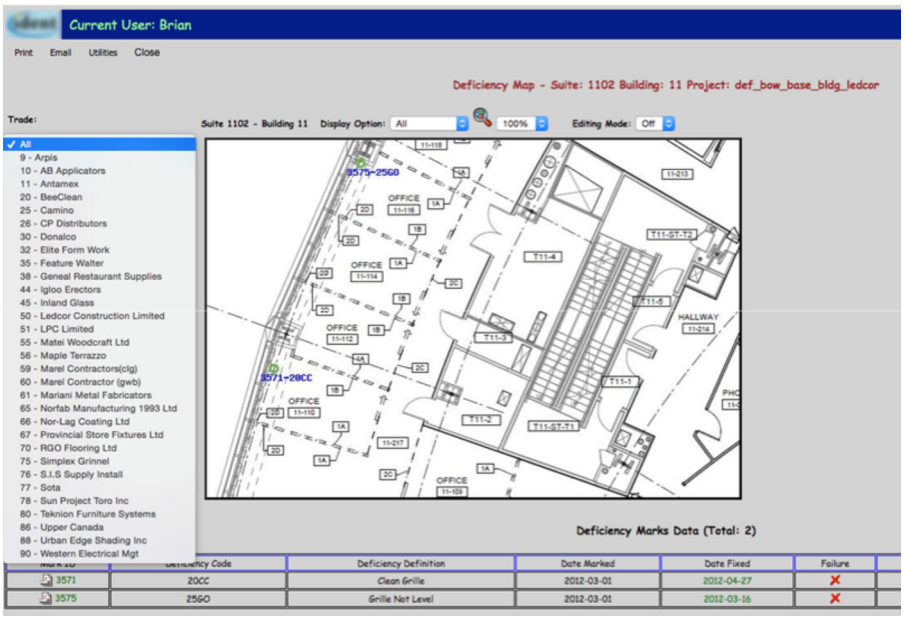

Figure 1.
A graphic-based data capture application

(2) Field-based quality issue management using smartphones with a text/speak/photo interface. This approach allows quick issue capture, with photo illustrations, and its communication to assignees and interested parties. It also supports phased consideration and closure, including for more complex issues where multiple trades or consultants are involved. Furthermore, it avoids the knowledge management data loss identified by Tan *et al.* (2010) as reducing knowledge capture and transfer across projects.

Two applications, one for document management, the other for issue management, were identified as clearly best from amongst the eight software applications being used by the project teams.

Field quality management implementation methodology

To manage the implementation of the recommended technology and expected reduction in quality-related costs, the business book, *The 4 Disciplines of Execution* (McChesney *et al.*, 2012) was consulted. It starts with the idea that a department or project team should have no more than two "wildly important goals" (WIGs) described as "[…] the goals that matter most. Failure to achieve them will make every other accomplishment seem secondary, or possibly even inconsequential" (McChesney *et al.*, 2012).

For a typical field quality management team, two WIGs were proposed: first,

The QOC for each project shall be $0.

QOC is currently the only quality-related metric that can be measured from the limited data available for each project. To support the first WIG, a second WIG was proposed:

Deficiencies on projects should be closed within one week of identification. Non-conformances should be closed within one month.

A one-week cycle for deficiencies is not unreasonable and allows focused weekly review. It is also recommended by construction insurers such as Zurich[2]. Non-conformances can be more challenging than deficiencies, as they may require material reorder/replacement, hence the longer time frame. One week and one month may seem aggressive, but the optimum

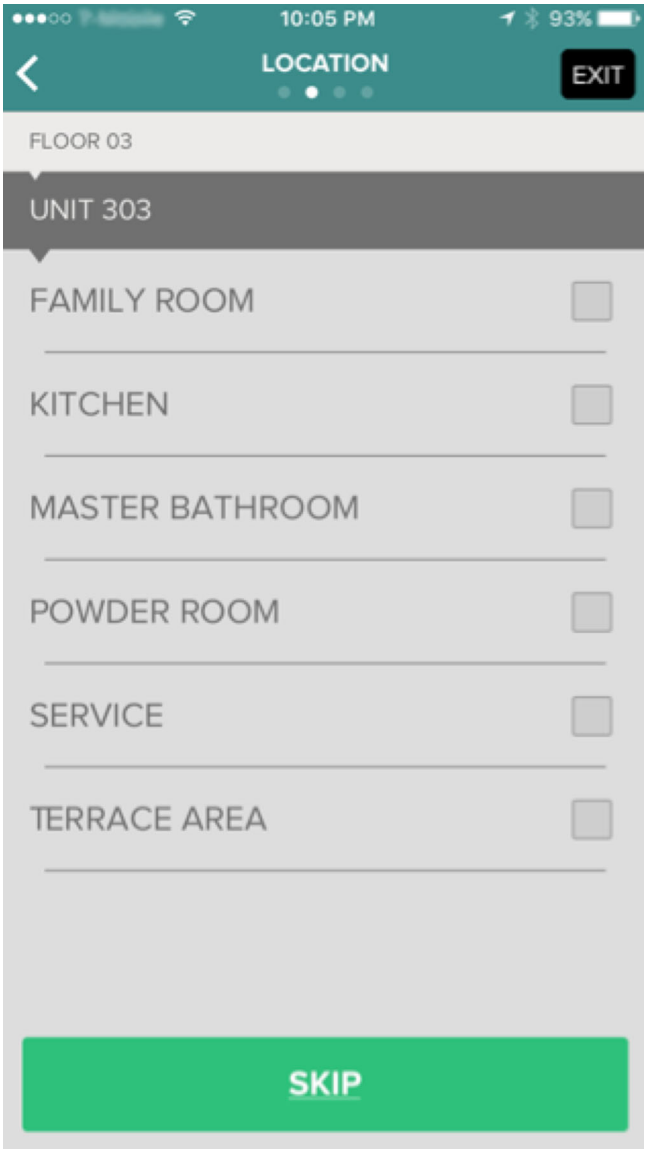

Figure 2.
A text-based data capture application

metrics will only be found by setting a target and measuring its validity for various project types and sizes. Field use of these WIGs is proving possible and cost effective.

When the recommended field quality management app is opened on a smartphone, a scoreboard is immediately presented, comprising of no more than four metrics:

In the sample below in Figure 3, an item added as a "Draft" (at lower left) becomes "Open" when key data such as location and assignee are added; when the item has been indicated as provisionally completed by trades or other assignees, it presents as "Pending Approval" (center illustration below).

	Functionality	Comments
	In the field	
1	Runs on smartphone	Important for day-to-day, continuous usage to capture issues
2	Simple interface	"Dashboard" desirable
3	Simple issues management interface	Assists in quickly navigating to existing issues and setting up new ones
4	Manages quality issues while in the field	Important to be able to easily update text and photographic information
6	Works online and offline	For work outside of cell phone range, e.g., below grade parkade, remote site, etc.
7	Easy photo taking and attachment	
8	Avoids photo file size buildup	Either photos are sent to "cloud" and cleared off hardware, or easily deleted if too much hardware memory consumed
9	Supports dictated notes	Dictation has improved so much that technical information may be successfully dictated
10	Report quality	User configurable or multiple logical formats
11	Issues filtered allowing multi-item reports from the field	Ability to issue a report from the field highly desirable
12	Immediate or delayed assignment from the field	Sometimes data needs to be reviewed before being issued
	In the office	
13	Broader team members can engage without licenses	If non-core team members need to "pay to play," they will not
14	Broader team can engage without extensive training	A steep learning curve will dissuade non-core team members
15	Produces Superintendent daily report	Desirable for superintendents
16	Produces automatic daily update reports	An alternative to Superintendent daily report
17	Integration with other management applications	Able to "push" data to other financial and project management platforms

Table II.
Key features comparison

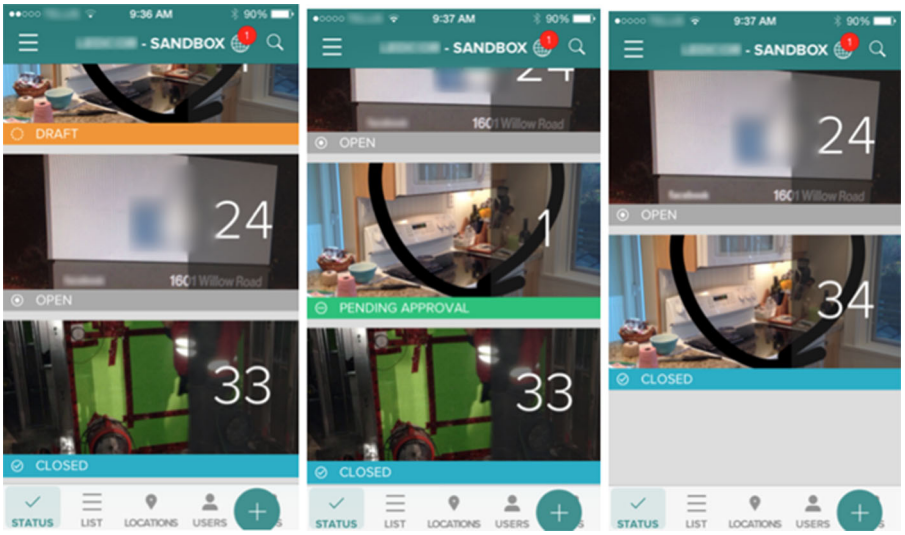

Figure 3.
Software login screens that track status of issues

When reviewed and accepted by consultants and/or contractor, it joins the "Closed" list (at upper right). In 4Dx terms, these measures are "leading indicators" – if items are efficiently moved from the "Open" to the "Closed" category, then the WIG of "$0 QOC" will more likely be achieved.

Although it was not written with 4Dx in mind, the recommended software is the only one identified for review that coincidentally presents each user with their project's visual "scoreboard" for WIG achievement. For use in the construction site trailer, this should be translated into an ascending line graph of open and closed issues as shown in Figure 4; the data can be taken from the login screen of the app just before each WIG meeting, and the list of open items printed or displayed as the meeting agenda.

This data review and presentation methodology has been trialed. Project teams report an improved focus by both contractor team members and subcontractors, once the relationship between lagging task closure, schedule and profitability are examined.

Communications staff have developed a branded scoreboard shown in Figure 5 suitable for mounting on a site trailer wall where a larger scale presentation is preferred.

4Dx recommends one other simple technique to maintain focus and accountability – a 20-30-minute weekly WIG team meeting at which the current state of the scoreboard is reviewed and commitments are made going forward. If senior management backs the WIGs noted above, the simple supporting framework of closely monitoring deficiency and non-conformance closures becomes straightforward to mandate and manage. This has been demonstrated in trials to date.

Accelerated implementation

Where an accelerated deployment approach is requested by management, in order to more quickly measure any performance improvements, then the recommended accelerated procurement and implementation process for construction operations is:

(1) Contact vendor to confirm in writing:

- General agreement for project support:
  - Trial period software costs.

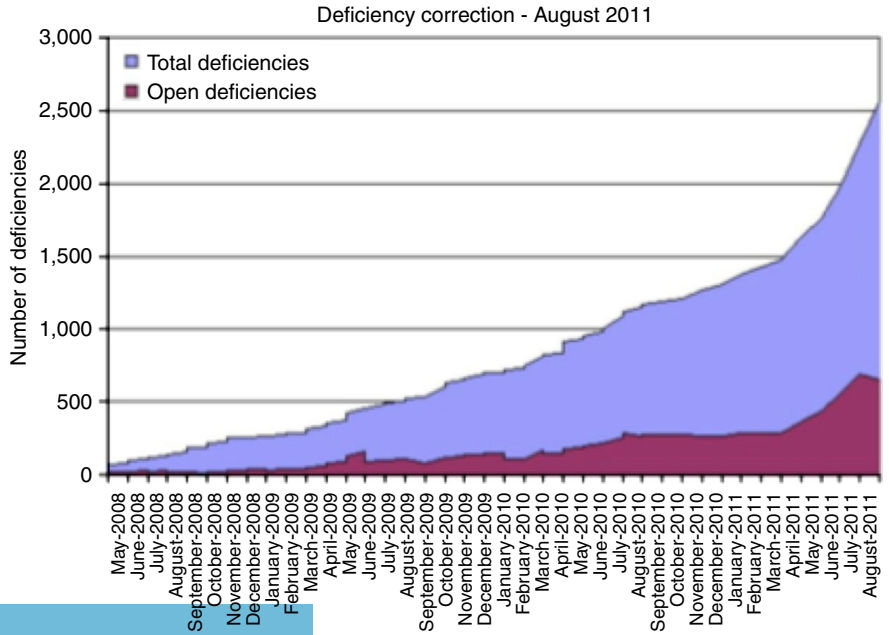

Figure 4.
Sample scoreboard for WIG

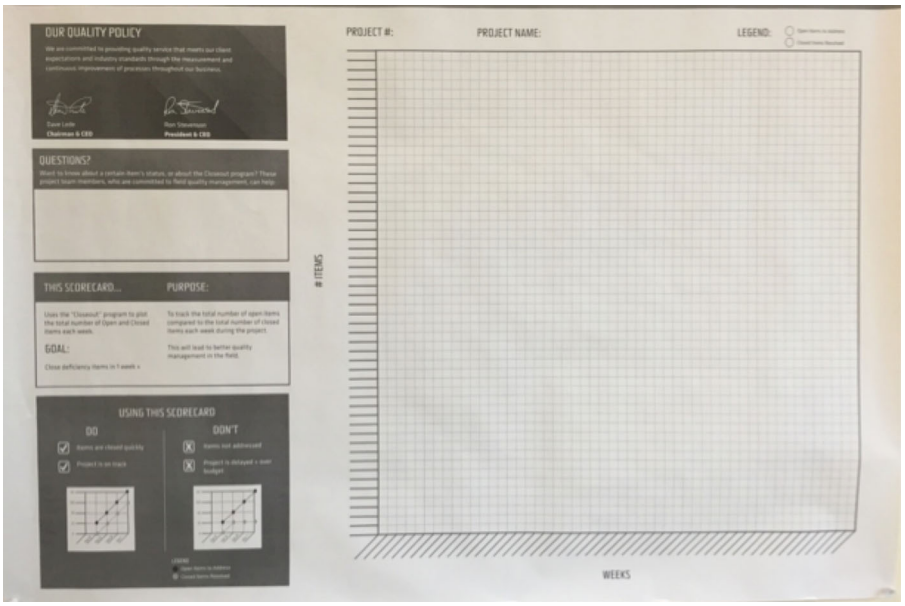

Figure 5.
Field quality management scoreboard

  - Enterprise agreement software costs.
  - non-disclosure agreement required.
- Security arrangements.
- Written agreement in principle to "push" data to other company software

(2) Conduct a six to eight-week trial of several projects for the purposes of identifying the selected software's fit and fitness:

- Identify projects and set them up on the software.
- Equip Superintendents and other on site project staff with correct hardware (smartphones with robust cases).
- Train trainers and project teams.
- Introduce and implement the software and hardware.
- Provide a scoreboard and monitor at weekly project WIG meetings.
- Report regularly during trial period and work with vendor to resolve any functionality, training or communications issues.
- Recommend go/no go at conclusion of trial.

(3) Assuming a positive outcome, convene a face-to-face meeting of all trainers, who are recommended points of contact in each branch and local training resources.

(4) Identify a post-pilot implementation project list:

- Preferably at least one project per branch office.
- Projects > $500,000 to provide sufficient scale for an initial evaluation.
- Projects < 50 percent complete ±, depending on project scale and branch, to allow enough project time to identify/measure performance improvements.

(5) Train staff in the management and use of the application – the product is simple to use, so this will not be an onerous task. As the product works in the field off smartphones, each trainee will need to be so equipped.

(6) Train staff in the conduct of WIG meetings and the care and maintenance of the scoreboard (Figure 5). It is not intended that trainers maintain these, rather that they understand the concept and show project teams how to set them up for use on site. Scoreboards will also give trainers and others an immediate quality snapshot when they are visiting a project.

(7) Equip the selected project teams with the recommended hardware and software and guide project teams through the project setup process – careful management is needed to ensure a positive start.

(8) Monitor the progress of the selected projects through weekly WIG meetings.

(9) Periodically visit with the project teams to observe actual use in the field, to identify issues and improvements.

(10) Include software assessment, QOC results and WIG review as part of each Post Project Review Meeting (PPRM).

(11) As new projects arise, engage their project teams with the objective of 100 percent enrollment in projects $>$ \$500,000 in construction value.

Conclusions

Capturing data about the costs of inattention to quality in construction is very difficult (Ashokkumar, 2014). In a construction organization of some depth (larger project cost volume) and breadth (multiple branches or regional offices), it becomes more statistically possible to: first, measure existing costs associated with inattention to quality; second, identify barriers to the adoption of techniques and technology that may improve quality performance; third, evaluate a range of options and select a small number of likely candidates to improve performance; and fourth, to systematically measure improvements in performance and financial terms, so as to evaluate overall effectiveness.

This paper describes a study that benefited from the scale and volume of work that allows for experimentation, evaluation and improvement measuring. Results are encouraging and may be scalable across different sizes and focuses of construction company.

Notes

1. "Disorganized e-mail" is not meant as a pejorative term, it refers to the use of conventional e-mail, which does not create database content independent of the individual user.
2. "Second Quick Win – implement a zero defects program – complete your scope of work with a zero punch list at the time of substantial completion; complete outstanding non-conforming items during the course of the project within seven calendar days of notification of the existence of the non-conforming work item" – from 2008 Zurich PowerPoint presentation, "Best Practices in Quality Management."

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About the author

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