

The Use of Mobile Devices to Create Value in Quality Management Systems

Blake E. Gleason, Paul D. White, Keith E. Kumpula, and Jeong-Han Woo, Ph.D.
Milwaukee School of Engineering
Milwaukee, Wisconsin

Quality management in construction is becoming driven by technologies that enable a smooth flow of information between all parties on a project. Many organizations are exploring the benefits of sharing information through real-time software to improve communication of current project information such as drawings, specifications, construction progress updates, punchlists, and issues. This research report aims to analyze three quality management software programs in the construction industry: Autodesk 360 Field, Bluebeam, and Latisa. The main objective is to validate the value of quality management software on a project and determine which software is appropriate for various sizes of companies if value is indeed added to projects. A process model of a quality management program with and without technology is presented to illustrate the benefits of implementing mobile quality management software into an organization. The research results suggest that each software program is beneficial to companies in different ways depending upon the specific situation, but all of them create value in a construction organization through increased collaboration and efficiency between all parties.

Key Words: QA/QC, mobile, benefits, software, construction

Introduction

Construction quality management is defined by the United States Army Corps of Engineers as "the performance of tasks, which ensure that construction is performed according to plans and specifications, on time, within a defined budget, and a safe work environment" (USACE, 2004, pp. 1-3). This process is traditionally done by large construction companies and consumes a significant amount of time and resources to accomplish correctly. Scanlin (1998) reported that communication consumes approximately 75% to 90% of a construction manager's (CM) time and information therefore needs to be current and available on demand (as cited in Jaselskis, Leming, Liu, and Vaughan, 2013). With the advent of mobile, web based software solutions; the process has become more streamlined and transparent for all parties involved. Mobile, web based quality management software allows a CM to create an issue in the field, attach a photo of the issue digitally, and then select a responsible party and notify them. Technology has transformed the process of creating a quality issue and reduced it from days down to minutes while at the same time increasing the effectiveness of the overall process.

Although many large construction companies have adapted mobile, web based quality management software, medium to small companies have not. Medium to small companies make up a large portion of the construction industry and their needs for a mobile, web based quality management software needs to be analyzed. In order to do this, an analysis of how quality management programs have benefited large companies has been performed and the results have been summarized and applied to possible solutions for smaller companies. Quality management software that will be examined in this paper includes Autodesk 360 Field, Bluebeam, and Latista. These products have increased many large companies' productivity, quality, and owner satisfaction; making them more competitive in the long run against their industry competitors. It will be determined if similar gains, such as these, are possible for smaller companies in the industry through the implementation of a mobile, web based quality management software.

Literature Review

A considerable amount of research in the past focuses on the collection of qualitative data in an effort to examine the cost-benefits of using some form of information technology to innovate the construction process. This paper will

look at various quality management software programs, and in doing so, identify a quality management software that is most compatible to mobile devices, valuable to large and small organizations, and financially logical. For this research a mobile device can be defined as any electronic device with an operating system capable of running software applications and also has Wifi capabilities. Such devices include Microsoft, Apple, and Android tablets, smart phones, and mobile computers.

A mobile component of a quality management system can streamline the process to reduce man hours and risk while increasing profit, quality, and transparency. This increases value not only for the contractor, but also for the owner and subcontractors. Implementing a quality management system that has mobile field capabilities can benefit a company substantially.

Quality management systems track all documentation in a cloud based environment. To implement a quality management system effectively there are some necessary requirements:

- Mobile tablet devices that support the software company's application.
- Licensing of the software system to place on a company's private server or to have hosted by a third party, such as the supplier of the software, that both company and non-company personnel can access from any location with an internet connection.
- Computers to access the reports that can be generated by the software.
- A quality assurance/quality control program already in place - the software is just a tool to streamline a current industry practice, it is leveraged with maximum effectiveness when a quality program is used by a company in conjunction with the mobile devices.

A Construction quality management (CQM) software program is best used when an existing QA/QC program is in place. Eli Lilly, the tenth-largest pharmaceutical manufacturer in the world, decided to create its own CQM program since multiple contractors delivered projects with quality issues. This was costing the company money since the manufacturing facilities were taking longer to bring online. The centerpiece of their new CQM program was Latista's mobile and web-based platform that decreased contractor rework during the owner commissioning process, reduced the overall project schedule and budget, and improved the end quality of their $400 million, 158,000 square foot manufacturing facility IE42 (Latista, 2011). Bruce Beck, Eli Lilly's Director of Global Facilities, Delivery, Commissioning, and Qualification Group, stated that "Construction Quality Management is not a given, it must be an expectation for the contractor. They must manage the process deliberately and demonstrate their capabilities. Activities must be measured and reported on so that performance can be improved….It must start with a fundamental commitment by leadership to instill quality principles into every aspect of the business" (Latista, 2011). A tool, like Latista, is only useful when a construction company supports and implements the fundamental procedures the software is designed to streamline.

Turner Construction Company implemented Vela Systems, now part of Autodesk BIM 360 Field, on the 10 Rittenhouse Square luxury condominium project in Philadelphia and the Hampton Roads Naval Housing project in Norfolk. Turner used the system not only to indicate mistakes requiring rework, but also note what work conformed to the contract documents. Ed McNeill, a Senior Vice President at Turner, stated that "With the great quality program we have in place, subcontractors are conditioned to do it right the first time, which is driving a very manageable, painless process of producing a quality level that is acceptable to our clients….With Vela Systems, we can define what quality means early on and establish this benchmark with subcontractors who can then get in front of the process and take care of repetitive issues before they waste time and money" (Autodesk, 2009). The system not only reduced risk for Turner by documenting conformance, but also for subcontractors on the project. Subcontractors were able to correct nonconforming work from the beginning and adjust their processes for the future - saving time and money for all parties. Monika Serrano, an Assistant Superintendent for Turner, said that it accelerated the field administration process. It use to take days to get observation reports from architects, and then it would take another day or two to input them into the appropriate form. With Vela the information went out the same day as the inspection to all of the right people (Autodesk, 2009). The mobile quality management software used on these two projects reduced risk and increased performance. The field personnel were able to do their jobs rather than attend to administrative work.

Rosendin Electric was the electrical systems subcontractor on the McCarran International Airport Terminal 3 expansion project in Las Vegas. The power of a mobile quality control system is not only seen by owners and

general contractors but also by subcontractors. Steve Braverman, Rosendin's Project Executive on the project, said that "Vela gives us the ability to do our work inspections, documents and reporting in real time, which lends invaluable credence to the Owner and allows the general contractor to process its paperwork much faster...guaranteeing the right information is delivered to the right people, and fast" (Autodesk, 2011). Their proactive approach to quality increased their profit. When a general contractor or owner places an item on a punchlist they do not have to pay for the rework to take place, the subcontractor or installer does. Mr. Braverman commented that "As contractors, we only get paid to put it in once. If we have to do it again, it significantly impacts the bottom line" (Autodesk, 2011). The quality management effort on a project is able to be accomplished from day one in an efficient and cost-effective manner when implemented with a mobile device.

Mortenson Construction implemented Bluebeam Revu and Bluebeam Studio on the Ralph L. Carr Colorado Judicial Center in Denver, CO to improve their communication workflow. Their intent was to move from a traditional paper-based process to a more feasible real-time project tracking software which enabled all members of the project team to receive, share, and review project information in real-time (Bluebeam, 2008). Real-time updates and tracking capabilities, enabled by the Revu sign off process, allowed Mortenson to eliminate walk through inspections. "Revu has helped revolutionize our approach to status tracking and documentation, making our workflows more efficient and visually easy to follow," said Dean Towl, Director of Project Planning for the Denver office of Mortenson Construction. "With Revu and Studio all information is live, with no lag in information sharing….We also have multiple access points to real-time data. Multiple team members can view and update completion and sign off simultaneously. And we don't have to worry about someone working in an older revision. We're all signing off the same sheet of music in real time," added Towl (Bluebeam, 2008).

Many organizations are exploring the benefits of sharing information through real-time software to improve communication of updated project information, such as PDF drawings and spreadsheets, project status updates, checklists, and contractor feedback. The case study of Gray Construction allows us to see how going paperless, with the use of Bluebeam Revu, can significantly cut costs and add value to the organization. Gray construction, an ENR Top 100 Green Contractor, has reduced construction submittal response time by 60% and reduced printing and shipping costs by 50% – all of this was achieved by going paperless with Bluebeam Revu (Bluebeam, 2010). "Bluebeam improves communication and reduces paper usage and shipping so much that the software pays for itself in just one submittal process," said Gary Hisel, Gray Construction Senior Design Manager. "It used to take us at least eight days and twelve overnight packages to receive, review, and respond to paper construction submittals. Now that we have Bluebeam, we're able to respond as quickly as three days, and we've cut shipping costs in half" (Bluebeam, 2010). Having the ability to review a submittal, mark it up in Bluebeam, and then return it to the submitting party all electronically increases the speed of the process and allows a QA/QC inspector in the field to be able to review the document on their mobile device.

Research Methods

To determine if the benefits discussed above are able to be applied to smaller construction firms, a structured interview was done with several local construction companies. The findings of the literature review were taken to make a questionnaire that would assist in discovering the possible benefits for a smaller organization, and also gauge what their current needs and knowledge base is. Each respondent was faced with identical open and closed questions.

The case study research provides an in-depth insight on each of the three software programs individually, looking at their compatibility with mobile devices, ability to accommodate businesses of various types, and the value they have contributed to past projects. A case study's primary goal is to link causes, effects, and relationships to provide in-depth data and understanding to its reader. The literature examined some of the largest and most recognized construction firms in the nation; providing data on multiple projects from different viewpoints. The information used originated from the software developer's website as well as other third party organizations. Examining three software programs and multiple case studies of each program was done to help ensure the research gathered remained unbiased. Direct quotes from project participants were used from the case studies whenever possible to ensure that it was as unbiased as possible, since the sources are not third parties.

Furthermore, a quality management program process model was created to better see the differences between a traditional quality control program and one that implements mobile, web based technology. These models were formed from the research performed and past experience on several projects of varying sizes that used and did not use a quality management software program.

Process Model of a Quality Management Program

Quality Control without Technology

The quality control process outlined is a generalization of a typical commercial construction project that does not use a mobile, web based quality management software program.

1. Subcontractor inspects their completed work and notifies the general contractor that it is in compliance with the contract documents and scope.
2. General contractor's superintendent begins the quality control inspection process once confirmation from the subcontractor is provided, examining the work in place and noting potential nonconformance issues down on paper.
3. Once back in the office, the superintendent goes through their notes and compares with the construction documents to identify any potential issues that exist. Additional notes detailing the concerns are made and handed off to the construction site administrative assistant.
4. The assistant creates the proper documentation, creating punch lists for the various trades.
5. Distribution entails placing copies of each list in the respective trades' mail slots in the office.
6. Hard copies of this paperwork are filed in the project documentation location and a digital copy is created.
7. Subcontractor examines the concerns listed and makes a determination of if, how, and when to correct.
8. Documentation is given back to the project administrative assistant from the subcontractor once rework is completed and the superintendent then inspects the rework to ensure conformance.
    - If it is unacceptable, the assistant documents the concerns and reissues instructions to the subcontractors for correcting the issue. This repeats the process.

Overall, the period for correcting these issues can approach two weeks once completed. Referencing the quality control process timeline for Quality Control without Technology as shown in a Business Process Model (BPM) in Appendix A, it is easy to see how a simple task in the construction process can contribute to an extended timeframe, increased use of manpower and financial resources, and potentially extending the contractual time agreed upon at contract signing.

Referencing the BPM for quality control inspection without technology, the site superintendent has the responsibility for seven steps (shown in green) in the model. The project administration assistant (shown in gray) is responsible for three steps, and the subcontractor (shown in blue) is responsible for three steps once a deficiency has been identified. These steps can be reduced with the use of mobile, web based technology.

Quality Control with Technology

The process described in this section will use the assumption that the general contractor and subcontractors on site have access to the same computer database and programs for project information through mobile devices and cloud storage sites. It is assumed that the general contractor has created a central repository of project information and required all subcontractors to show the ability to access and use the system via laptops, tablets, or smart phones.

1. Subcontractor begins their QA/QC requirement by reviewing all construction documents, addendums, and change orders applicable to the current stage of work. Checking the database, the subcontractor confirms compliance to contract documents and photographs work in place to document completion on a preformatted progress report that loads directly into the project database. Subcontractors can document work completed without the need of the general contract getting directly involved.
2. The site superintendent reviews the progress reports which document the date of completion and provides evidence of conforming work. This documentation also assists project engineers in maintaining the project

schedule and draw requests. Once all trades have signed off work for particular component of a project, the superintendent has confidence that an inspection is ready to be performed, decreasing the chance of incomplete work requiring an additional visit to complete initial inspections.

3. The GC's superintendent can begin his visual inspection of the work in place and document discrepancies or deficiencies noticed in the field. They are able to create an issue, take a photo, and assign the new issue to the proper subcontractor all while in the field.
4. In the field, or in the subcontractor's office, the responsible party reviews the information and self-inspects, or assigns someone in the field to inspect, and determines their level of responsibility and obligations to the identified problem. Once a decision is made the issue is either corrected or disputed quickly. The subcontractor can document their findings and/or the corrections they made on the issue and update it electronically in the GC's quality management software.
5. The GC's superintendent easily monitors progress, discrepancies, or disputes and addresses them in a timely manner. Follow-up on quality issues can be accomplished through email, text, or phone communications to determine at what stage the subcontractor's rework is at.
6. When the subcontractor changes the status of an issue in the quality management software the GC's superintendent or quality manager will be notified. They are then able to go and inspect the corrections in the field and update the status of the issue on the mobile device. If the issue is not corrected satisfactorily the GC can notify the subcontractor by changing the status in the system and the process repeats. If it is approved then the GC can close the issue notify the subcontract that no further action is needed. This is all done electronically and instantaneously to drastically reduce the time a quality issue takes to be resolved.

Through all the steps described above the projects administrative assistant can monitor progress. If necessary, hard copies can be easily kept on file at the site or home office for future reference. This work can be done when the admin has time as opposed to the previous process, which lacked technology, where their involvement was crucial to keeping the project on track. The site superintendent has four steps, reduced from seven; the admin has one non-critical task reduced from three critical.

According to Kim and Kim (2011) there are many problems that are associated with running a quality inspection program (QA/QC program) which impact a contractor's ability to manage efficiently.

- Time requirement for participants recording information, first in the field and second in the office.
- Inconsistency in monitoring whether items have been corrected completely or correctly.
- Lack of manpower.
- Poor communication among project participants.
- No central depository of information and associated feedback system.

By leveraging available software programs and mobile devices tied to cloud based systems, these issues become less concerning and problematic to the General Contractor or Construction Manager. Technology exists to streamline the noted inefficiencies and shortcomings to decrease manpower constraints, reduce schedule durations, increase profits, lower rework requirements, and increase owner satisfaction. So why are the techniques not being used by the contractors industry wide? A typical response may center on the fact that contractors do not see value in implementing programs that are perceived to deliver little value against the understood benefits.

Referencing the business process model for a quality control process using technology, the use of mobile devices and computer databases significantly impacts the required steps in the lifecycle of a QA/QC issue. Responsibilities for the quality control supervisor are cut down from seven steps without technology to four steps with technology. The project administrative assistant's responsibilities go from three required steps to one step that can be done when time allows. In the subcontractor's case, the required steps remain at three. However, the ability to reference and confirm compliance with the contract documents, addendum, or change orders can easily be done from the field.

Reduced steps and a lean, streamlined business process model contribute to increased workflow, reduced schedule time, and most importantly a reduction in money spent on additional or unnecessary man hours that in the end deliver the same product for the same price.

Results

The structured interviews conducted with owners of smaller organizations allowed evaluation of the organizations' current state of QA/QC management, the employees or subcontractor's technological experience, as well as some of the challenges implementing QA/QC software. The below table illustrates that organizations A, B, and C do not currently use any form of mobile technology for quality management purposes. Respondents were asked their level of technological experience on a scale of 1-10 (1 being illiterate, 10 being savvy) followed by the experience of their subcontractors or employees. It was found that organization A, C, and D reported having 3+ incidents per project where subcontractors did not have updated plans or drawings resulting in some form of rework. All respondents found that the use of a QA/QC software program would benefit their organization. When asked the number one challenge in implementing QA/QC software all respondents addressed the issue of their subcontractors' and employees' inability and desire to use mobile quality management software.

Results of structured interviews with small business owners

Item	Questions	Rob Miller Builders	Mac Paving	Surprenant Masonry	Envision Builders
1	How many people do you currently employ?	4	10+	7	1
2	How many subcontractors/employees are involved on a typical building project start to finish?	13+	3-6	3-6	13+
3	Do you use any form of technology for quality management?	No	No	No	Yes
4a	On a scale of 1-10 (10 being tech savvy) how would you rate yourself?	6	7	4	5
4b	Your employees/co-workers if applicable?	8	3	4	
4c	Your subcontractors if applicable?	4			4.5
5	Over the last 3 years, how many projects are you averaging per year?	7+	7+	7+	5-6
6	What are some common issues you come across in a new project?	Communication	Deadlines & weather	Owner changes, meeting deadlines due to others	Craftsmanship
7	Would quality management software benefit a small business like yours?	Yes	Yes	Yes	Yes
8	Do you ever have issues with subcontractors or employees not having updated plans or drawings resulting in some form of rework? If so, how often would you say on each job?	Yes, 3-4 times	No	Yes, More than 5 times	Yes, More than 5 times
9	What do you think some of the challenges would be to implement quality management software?	Introducing and teaching subs	Employees technology illiterate	Technological Illiterate	Subs technologically illiterate

Conclusion

After researching the three different software programs and speaking with local construction companies, it has been concluded that Bluebeam is the best choice for smaller firms. Bluebeam is a PDF software that can do estimating, markups, and other tasks that are common on a project besides just the QA/QC aspect. Autodesk 360 Field is an

excellent choice for companies who regularly utilize Building Information Modeling (BIM) on projects since it has the capability to link to the intelligent model. 360 Field leverages the capabilities of BIM and increases the flow of tasks that is usually associated with the utilization of a BIM model. Latista is a good choice for large companies who do not regularly use BIM but still do complex work. Latista has a dashboard capability, so a company executive can see quality issues across all projects a company is currently undertaking. It can also keep excellent documentation and supports a large project's needs. All three of the products are suited for different situations and meet the needs of different companies. The products all have similar end outcomes though – increasing productivity and communication while reducing rework and delays. This provides strong evidence that the implementation of a mobile, web based quality management software is beneficial for companies of varying sizes in different market sectors.

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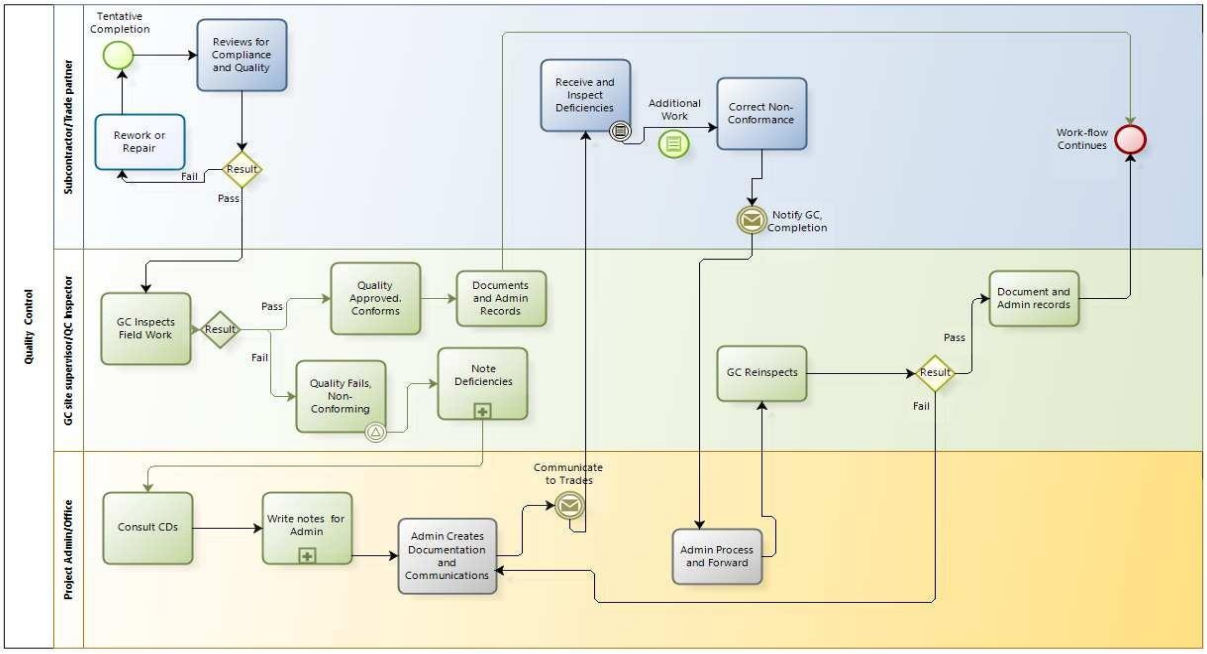
Appendix A

Process map showing the quality control process without using technology



Appendix B

Process map showing the quality control process with the use of a mobile, web based software