

Designing a Project Management System for Owner Representatives at Public Georgia Universities

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The construction industry has had difficulty adopting project management software effectively and in a widespread manner, despite a general acceptance of potential benefits that such software can bring. This research project seeks a user-centered approach to uncover common problems preventing the adoption of new software for construction project management, and to utilize a method to design more successful software. The goals of this research were to better define the functions of project management software, as well as uncover benefits both realized and anticipated. A Situation Awareness based approach was selected to result in proposing a prototype application that would specifically match the mental model of the users. To define the mental model of the project managers that would use the software, a Goal Directed Task Analysis (GDTA) method was used by way of an online survey and in-person verification. In order to collect the survey data, a web based GDTA application was created and tested as a part of this research project. Using the survey data, a proposed design for a prototype application was generated and the application design was specifically made to fulfill the needs of project managers. The GDTA method proved effective in producing a software design. Recommendations to create and test the proposed prototype application are provided as a next step.

Keywords: project management, construction management, software, GDTA, situation awareness.

Introduction

A construction manager who represents the owner must make decisions that determine the direction of a construction project from the earliest stages through the start of occupancy. These construction managers have limited resources to accomplish the project goals. There has been a continuing shift in the AEC+FM (architecture, engineering, and construction plus facility management) industry to move toward computerized information systems (Michaloski & Paula, 2010; Rivard, 2000). While there is widespread agreement that IT systems are beneficial in the construction and facility management industry, difficulty with implementing solutions effectively and defining the benefits in a concrete way still exists (Hassan Issa & Abu Hassan, 2011). In a study that categorized and ranked existing software, Scott, et al. (Scott, Kwan, Cheong, & Li, 2003) concluded that there is a need for construction information management systems that are better targeted at the specific needs of people in the industry.

There are a large number of software options for project management available. These options all vary in licensing, functions, platforms, targeted users, and capability. The Construction Financial Management Association surveys contractors every two years regarding their adoption and use of technology. From their 2004 survey 17.9% of contractors surveyed were using project management software (Sawyer, 2004). By 2010 this number had increased to above 70% (Construction Financial Management Association, 2010).

Project management software, as referred to in this paper, is defined as computer software designed to assist with the process of managing a construction project. Such software might be classified in any number of other ways, such as decision support software or a document management system, but if the purpose is to aid in managing a construction project then it is also project management software. Project management software may perform a variety of functions, work on different platforms, and be used by different participants in a project. Project management software can include a wide range of uses and features. To illustrate construction project management functions I derived the mind map shown below. Many programs are specifically targeted to certain functions, such as Microsoft Project for scheduling. Other programs are for more general applications but can be adapted to fit these needs, such as using Microsoft Excel for estimating.

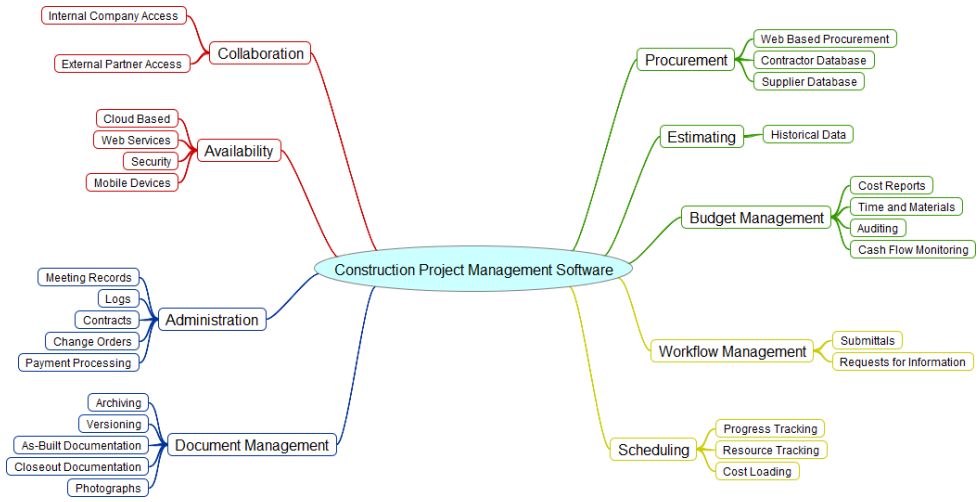

Figure 21 - Mind Map of PM Software Functions

Issues hampering the effective adoption of construction information management systems include a lack of knowledge management, inconsistent competency with technology, a lack of interoperability between technologies, poor training, and software that does not fit the needs of every team member (Owen et al., 2010)(Michaloski & Paula, 2010)(Hartmann, 2009). New systems are also intended to improve processes; but it is also possible that new systems create redundancy and added complexity (Adriaanse, Voordijk, & Dewulf, 2010). Making matters worse, is a very low rate of investment in technology in the construction industry compared with other industries (Becerik-Gerber & Rice, 2012). The ongoing problem of finding an effective way to integrate project management software that provides tangible benefits requires a new approach. A Goal Directed Task Analysis approach was selected for this study, because it has been proven to be an effective approach for user interface design (Endsley & Jones, 2004). By using a Goal Directed Task Analysis method an application was designed that starts with the fundamental goals of the project manager, and uses that to inform the parameters of the application.

Methodology

In order to design project management software that meets user's needs, a user centered design approach needed to be used. Situation Awareness is part of a user centered design approach, and is defined as being aware of what is happening around you, organizing that information, and being able to project in to a future state (Endsley & Jones, 2004). The GDTA method models the Situation Awareness of the person being interviewed, producing results that can be used for user centered design. This research explored definitions and functions of project management software, researched studies that have documented problems with software adoption in the industry, and then utilized a GDTA approach to propose better software design. In order to collect a large amount of data a web based GDTA survey tool was created and tested, and ultimately sent to 83 potential respondents. Potential respondents were limited to owner representatives who directly manage construction and/or design projects as part of their job duties at public universities in the state of Georgia. This group was chosen for the study to limit the effects of

studying a wide range of owner types over different regions. The GDTA method was chosen because it is a proven technique used to determine the goals and needs of experts in a particular field (Gheisari & Irizarry, 2011). GDTA typically involves a series of structured interviews. This method was emulated in the software based approach, but typical in-person interviews were also conducted to provide validation of the software based approach, and improve the quality and detail of the data collected.

GDTA surveys involve identification of the goals of an individual in their work task, determination of key decisions that must be made to accomplish those goals, and identification of the information needed to correctly make those decisions (Endsley & Jones, 2004). The GDTA process is not concerned with the particular mode of collecting the information, but rather with the value and accuracy of the data collected (Endsley, 2001). The end result of the GDTA process is a hierarchy composed of individual pieces of data organized relationally. The hierarchy consists of a central goal, sub goals that must be achieved to accomplish the central goal, decisions that must be made in order to achieve each sub goal, and the information needed to correctly inform those decisions. The end result is data that can be used to improve system design. The web based survey tool created for this study asks a series of questions to establish the basic information about the respondent and their experience and impressions about software used for project management. Then the survey goes on to explain the GDTA method and prompt the user for their job goals, key decisions, and information needs. Their answers are illustrated in real time as a hierarchy diagram. When the user is satisfied with the results he or she can submit the survey. Therefore each survey submitted consists of a questionnaire response portion, and a GDTA hierarchy portion.

The questionnaire portion of the survey consisted of 20 questions with a mix of multiple choice and short answer types. The questions first cover the respondent's education, experience, specialty (e.g. architecture, engineering, construction management), age, and gender. Next the questions cover the respondent's current work practices with mobile devices, project management software, and storage of data. Finally the questionnaire covers the respondent's past experiences and impressions of project management software, including problems and successes. The results of both the questionnaire and GDTA portions of the survey were important in defining the key functions needed for the proposed prototype project management application. The questionnaire portion provided a profile of the respondent and sets the context of the GDTA information provided by establishing the respondent's background and experience. The questionnaire also collected feedback about past experiences with project management software, and impressions about how useful it can potentially be. These answers were intended to be used to contrast with the data collected in the literature review concerning industry adoption, difficulties, and impressions about project management software. A diagram of the methodology is shown below.

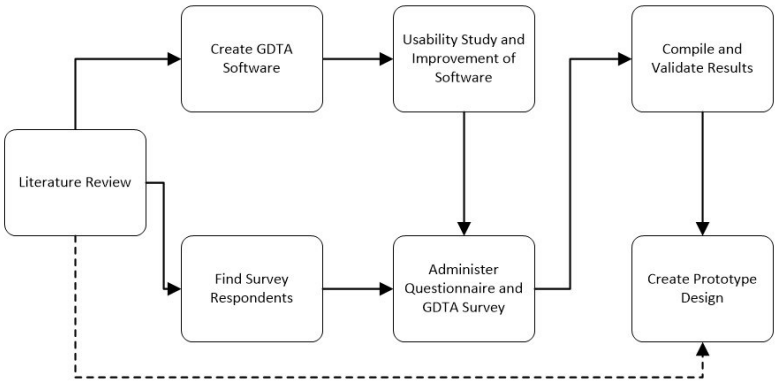

Figure 22 - Methodology

Survey Results

Eighty-three respondents who potentially manage construction and/or design projects in their work at universities in Georgia were contacted. Of these, 34 responded using the web based survey application. 211 individual pieces of data were provided in the online GDTA portion of the survey. Each piece was a node on a GDTA hierarchy from individual respondents. A sample GDTA hierarchy is below. These pieces were used to create a single unified

mental model, representing the hierarchy of needs of a construction project manager working at a public university in Georgia. This unified model was reviewed with select respondents in person for validation and additional details to create a final model. The questionnaire results from the survey reinforced many of the findings from review of previous studies.

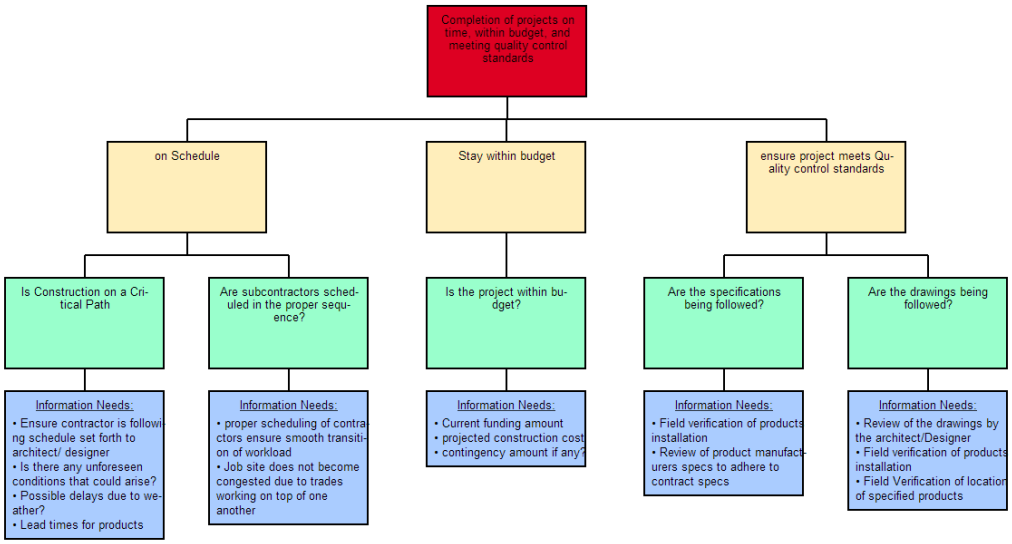

Figure 23 - Sample of a single GDTA response

A variety of background and experience levels were represented in the responses. Most commonly, respondents were males (65%) between the ages of 36 and 56 (55.87%), with 20 years or more of industry experience (50%) and at least 5 years in their current position (55.94%). Most were highly educated (88.24% had Bachelor's degrees or higher), and respondents were split between design backgrounds (52.94%), engineering backgrounds (17.65%) and construction management backgrounds (20.59%); with the remainder having field experience (5.88%) or facility management background (2.94%). 93% of respondents use a desktop computer at work, and 73.5% use a smart phone, while much lower percentages used laptops (20.6%) and tablets (14.7%). Respondents indicated that mobile technology was very useful and important in their work. The overwhelming majority of respondents indicated using paper records (100%), email (97.06%), PDFs (97.06%), and spreadsheets (91.18%) to store and organize important information for their work.

A majority (58.82%) also indicated use of Computer Aided Drafting (CAD), Building Information Modeling (BIM), or Computer Aided Facility Management (CAFM) software. 23.5% of respondents indicated use of scheduling software, 20.6% indicated use of note taking software, and 8.82% indicated used of budgeting software. 11.76% indicated use of PM software, but when asked what that software was, only 2 respondents indicated use of software actually design for project management The rest indicated use of specialized programs such as scheduling software (one component of project management). Many respondents had used specialized scheduling software, budgeting software, project management software, and other specialized software in the past (58.8%). Respondents also provided feedback about this software indicating problems experienced:

- Poor support
  - A lack of training
- Poor Usability
  - Difficult and confusing interfaces
  - Poor mobile support
  - Lack of interoperability with systems used by the rest of the project team

- Poor Implementation
    - Information overload due to too many features
    - Duplication of entry to get data into software without replacing existing systems
    - Difficulty getting the entire project team to use the project management system
- Poor Results
    - Software doesn't provide useful information, or doesn't provide it in a usable way
    - Quality of results are only as good as the quality of the information in the system

Despite this low rate of usage of PM software, and somewhat negative feedback, the majority of respondents indicated that PM software was very important to their work. 70.6% of respondents indicated that PM software improves the likelihood of project success, meaning that while 24 respondents felt this way, only 2 respondents actually used software designed specifically for project management. Respondents were split evenly when asked if PM software increased their workload rather than decreased it. Positive feedback received about PM software included improved communication and better management of budgets and schedules. One respondent indicated that PM software is designed primarily for contractors and designers, rather than meeting the needs of owners.

Proposed Prototype Application

The GDTA portion of the survey provided a combined hierarchy of needs that could be directly translated into a set of software requirements for a prototype application. Taking this data and combining it with the questionnaire results, and knowledge gained from research of previous works, resulted in a complete set of software requirements. These requirements address both the goals identified in the GDTA, and the hurdles that need to be overcome to improve adoption and success of implementation. These requirements began with a simple set of 10 basic needs:

1. Assist Tracking Project Schedule
2. Assist Tracking Project Budget
3. Track Project Requirements
4. Assist with Standards Compliance
5. Assist with Procurement
6. Enable Effective Communication
7. Support Mobile Platforms
8. Ease of Use of Software
9. Capture Worker Knowledge
10. Provide System Interoperability

Each basic need was expanded in to a set of software requirements that would fulfill that need. Tracking schedule requirements requires the software to allow a schedule to be defined, provide status updates, link scheduled tasks to responsible parties, track potential schedule risks, indicate the critical path, and track resource usage.

In order to track budgets the software must provide a history of budget changes over time, track the status of the budget in relation to commitments and projected expenses, associate the budget development milestones with the project schedule, utilize budget information to assist in change order decisions, track the status of change orders, provide tools for value engineering decision, and track the status of value engineering decisions. Project requirements are defined as the specific goals of the individual project. These requirements must be met in order to classify the project as successful. The software must provide a method to document these requirements, model the project team structure in to the software, assist in managing customer expectations, and document needs for project support. Additionally the need to connect an individual project to the higher levels goals of the entire university such as a master plan or branding efforts, is needed. Post-occupancy support was also a need identified, so that the software must provide a way to track validation that the project requirements have been met. To assist with standards compliance the software must be able to catalog all applicable standards, and track compliance with those standards. Commissioning tasks also must be tracked and quality control activities must be tracked to ensure that the end product actually meets the required standards. Assistance with procurement activities was limited to assistance with selection of a procurement method and assisting with procurement agreements. This would manifest as analyzing potential impacts of different procurement methods, such as schedule and budget changes, and

associating the project team members with specific agreements for scope and price – all tied back to the project schedule and budget.

Because communication problems were identified as a major problem in the literature review, questionnaire, and GDTA, it is fundamental to the success of the software. If information is not communicated effectively then it is useless or even harmful. To assist with this need, the software must model the communication plan for the project in order to inform users about compliance with the plan. Workflow should also be automated so that the software automatically forwards information and states the actions needed from the recipient. Auditing the workflow is also an important function in order to provide verification and analyze bottlenecks and responsiveness. The prevalence and importance of mobile devices was indicated in the research and questionnaire responses. To respond to this need the software must provide a web based interface in order to maximize the number of devices that can access the data, as well as provide mobile client applications for a rich user experience. Data must also be available both online and offline so that users can continue working even where there is not an active internet connection. Data should be able to be synchronized over the internet so that information can be uploaded to the system and shared regardless of the local network, as long as there is an external connection.

Ease of use was another issue identified in the literature review as well as the questionnaire. This is associated both with the productivity impact of the software as well as the willingness of the users to work with the software and rely upon it. To improve ease of use the software must provide assistive help (contextual and timely), provide in-depth help when the user requests it, and utilize recognizable user experience design patterns. Another very important factor to improve ease of use is a usability study, so that any impediments to user success can be identified and remediated. With a system that provides a large range of capabilities, such as the one proposed, the design of the interface and help system is ciritical to ease of use. Users should not be overwhelmed with complex navigation and choices which are not necessarly relevant to what they are trying to accomplish. A usability study can help determine the specific use cases in order to help lead the user to only the components that they need. As a simple example, when a user has not yet defined a schedule in the system, they shouldn't be presented with a complicated array of schedule related options or errors. In scuh a scenario they should simply be prompted to start entering a schedule. The most relevant options based on the state of the project data, the user role, and the context should determine what is presented and suggested to the user.

The need to capture worker knowledge can be addressed by integrating with other knowledge management solutions, such as a private corporate social network system. Allowing the users to manage a personal profile and post information or questions within the system can provide a mechanism to document and share worker knowledge. Interoperability was the final need identified, so that the program can be extended and interact with other applications to maximize the usefulness of the information it contains and the capabilities it can provide as services. In order to do this, an API (application programming interface) should be provided. An API allows external applications to call functions within the software. Utilizing open and common standards is important to make information conform to established norms. Web services utilizing RESTful type calls is another way to make the application more interoperable and available to a wider array of platforms, including mobile devices. Providing a flexible backend can allow IT staff to utilize existing data infrastructure or cloud infrastructure as well, making implementation easier.

Conclusions

The survey and literature review indicated that the majority of project managers in the subset studies perceived a high level of potential value in project management software, but that almost none of them actually utilize it. Those that had used project management software in the past had specific difficulties prevent it from being more successful. The GDTA method allowed the derivation of a design that would potentially resolve these issues. Additionally, the web based GDTA software proved to be useful to collect a large amount of GDTA data. It is recommended that the software not be used as a total replacement to the in-person GDTA method because the in-depth back-and-forth discussion elicits more details. In-person interviews cannot collect data as quickly from so many respondents though, so the two methods combined proved to be useful. When collecting a large amount of GDTA responses, it is easy to see where the common threads are, and where individuals tend to deviate. The next step for this research would be the development of an actual prototype application for testing, based on the results of this study. That application could be tested for usability, improved, and then analyzed in a pilot study to collect data

providing a direct comparison on effectiveness over other applications, and how well it achieves the goals set in the software requirements. The web based GDTA software can be made available for continued development by others through an open source license.

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