

DEVELOPMENT OF A PROJECT MANAGEMENT SOFTWARE TOOL: A DESIGN CASE

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JBPM software is the result of a need to have easy to use software that supports the teaching of project management at both the undergraduate and graduate levels of instruction. Existing project management software offerings are not conducive to learning project management techniques as specified in the Project Management Body of Knowledge (PMBOK).

This case details the development of the software and describes its use in real world projects. Additionally, it presents empirical evidence that students find the software easy to use and that it enhances their understanding of project management concepts.

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<https://doi.org/10.14434/ijdlv9i1.23344>

INTELLECTUAL BACKGROUND

JBPM software is the result of the perfect storm of the demands of teaching a project management course colliding with the lack of an adequate option for project management software.

Project Management Course Objectives

It is common that information systems (IS) program curriculum have project management as one of its core courses. The 2010 AIS/ACM curriculum guidelines list project management as one of the seven courses that should be part of the foundation of an IS curriculum (Topi et al., 2010). In addition, business students should get familiar with individual or team project management because it is one of the important skills for business (Cowie, 2003; Yamagata-Lynch & Paulus, 2015). What research exists on project management teaching practices focus on what concepts and skills should be taught (Baird & Riggins, 2012; Du et al., 2004; Frank, 2010; Landry & McDaniel, 2016; Pollard, 2012; Reif & Mitri, 2005; Smith III et al., 2008). As an applied subject with a direct career correlate in industry, there is an increasing expectation that project management courses be taught with the assistance of project management software. This is due to an increasing number of IS projects in industry being managed by software. Thus, including project management software into a course is a reasonable direction to take. This begets the question: which software package to use?

Project Management Software Options

Although this design case was written as a collaborative research effort, the development of JBPM software was performed by only one of the authors. For this reason, most of the design decisions are discussed from the first-person perspective. As the software developer, I explain what I was thinking and why I chose to do things the way I did. As with any endeavor the context in which it happened was important.

After a fall semester teaching a project management course to undergraduate students, I began preparing to teach it in

the spring to graduate students. I had taught the subject for a couple of years, and I had always used Microsoft Project as the software tool students used to manage their projects. This particular fall semester I remember sharing the students' frustration with using this software. It was obvious they became more confused about how to manage projects after using the software. It was also clear that I needed to spend several weeks teaching them how to use the software effectively. Important functions like calculating earned value do not work properly unless the project is set up just right.

As a general nerd and a fan of open source software, my immediate thought was, "there has to be an open source software available for project management." I was wrong. I started looking through different options, and I knew that I needed a minimum set of requirements to be met. To be ideal, the software package had to meet the following five criteria:

- Free
- Easy to use
- Steep learning curve¹
- Support for real time collaboration
- Support for the most important project management functions

The software needed to be free because the students already had access to Microsoft Project for free. It needed to be easy to use with a steep learning curve because I did not want to spend half of the class teaching the software. I wanted to spend my time teaching the important content related to managing projects. It needed to support real time collaboration because that was a frustration I had with Microsoft Project™. This software was file-based, so students would email the file back and forth and add their changes. This led to multiple problems with version control. Finally, the software needed to support the most important project

¹ Colloquially, *steep learning curve* refers to something that is hard to learn, but 'a *steep learning curve* means learning takes places quickly.

management functions because I needed students to implement the things we were doing in class.

Upon surveying the project management software marketplace, no suitable software package could be found. For example, students have access to Microsoft Imagine and can download and install Microsoft Project™ for free. While it is a good product, and a market leader in the project management software space, it did not fulfill several of the above general requirements: Those being support for collaboration and being easy to use. While Project™ does support the most important project management functions, students have a very difficult time doing earned value analysis correctly. Table 1 shows the results of the search of the project management software marketplace.

Because none of the major commercially available project management software packages fulfills all five requirements, I decided to build a custom tool to meet all five criteria. Hevner et al. (2004) defined seven design-science guidelines, and these provided the roadmap for this project. Currently, the most important guidelines have been completed, and JBPM has been evaluated by students in project management classes. Boling (2010) defines a design case as "a description of a real artifact or experience that has been intentionally designed" (p. 2). As a design case, this paper was written to share our artifact and experience with other designers and/or instructors. The rest of this paper describes the design of the software system, the implementation, the evaluation by students, and the next steps to be taken.

THE PURPOSES AND REQUIREMENTS OF JBPM

JBPM software was designed to address two complementary goals that had been ignored as quality instruction in project management concepts and use of a PM tool to enhance real world transferability of such concepts. Project management professors often do not have the time to develop a new piece of software that will seamlessly integrate with course objectives. In my experience, software engineers do not care about course objectives, but rather they design robust

PROJECT MANAGEMENT SOFTWARE PACKAGE	OBJECTIVES [‡] IT MEETS	OBJECTIVES IT FAILS
Microsoft Project™	1, 5	2, 3, 4
Oracle Primavera™	4, 5	1, 2, 3
Trello™	1, 2, 3	4, 5
Basecamp™	2, 3, 4	1, 5
Smartsheet™	2, 5	1, 3, 4
Huddle™	2, 4	1, 3, 5

[‡]Objectives refer to the five criteria of free, easy to use, steep learning curve, real time collaboration, and support for important project management functions.

TABLE 1. Review of major project management software packages.

enterprise project management applications that assume users already have mastered the underlying project management concepts. Starting with a blank slate maximizes the chances that JBPM software will meet both goals.

Purpose I: Seamlessly Fulfilling Course Requirements

Prior to any sort of software design, the requirements for the new software must be clearly defined. This entails matching course objectives to software capabilities. The JBPM software had three main capabilities it needed to address related to basic high-level PM concepts: (a) the application of solid methodology, (b) the managing of costs, and (c) the ability to share information with relevant stakeholders.

Although teaching project management was the primary objective for the software, it is important to understand the context of this project. In the process of developing the software, I was hired as a consultant to manage a software implementation for the medical practice of a couple of surgeons. Actually, I was involved with the surgeons a few months earlier when they were making the decision to choose a vendor for their practice management software. They chose (against my advice) the low-cost provider. This provider did not do any formal project management for the software implementation. They gave customers access to the software and a week of on-site training.

I ran into one of the surgeons two weeks into the implementation, and he told me how poorly things were going. I offered to manage the project for them, and I was hired. The reason this matters is because supporting formal project management methodology took a back seat for a few weeks. During this time, I spent most of the development effort focusing on the management of issues and the sharing of information through progress reports. These functions are important when executing a project, but they are not the most important aspects of teaching.

One of the most fundamental tenets of project management is to apply good methods. In teaching, this means using the Guide to the Project Management Body of Knowledge (PMBOK, 2013) as a resource to define the important components of project management. Because this structure is known and used globally by Project Management Professionals (PMPs), it was decided to use the PMBOK as a foundation for the menus and functions of JBPM software.

The three pillars of project management are being on time, on budget, and within scope. However, it can be very difficult to know how a project is doing without good earned value information. Knowing when to end a project can give an organization a strategic advantage because significant resources are wasted on failed projects (Keil, 1995; Schwalbe, 2015). Project managers need to know if a project is on schedule and on budget to make good decisions (Caniëls & Bakens, 2012; White & Fortune, 2002). Therefore,

earned value analysis needs to be a core component of a good project management software system (Liberatore et al., 2001). To implement this functionality, JBPM software needs to support the monitoring of resources and related costs (De Wit & Herroelen, 1990; Larson & Gray, 2014).

In today's interconnected world, collaborating and sharing information is critically important. In past consulting projects, one of the authors had searched through old email threads with programmers to find information that needed to be shared with a client. This practice is inefficient and can be detrimental in the long term because someone might need that information in the future. Issues such as turnover or promotions or professional relocations mean information can be irretrievably lost, a concept known as organizational forgetting (Fernandez & Sune, 2009). Therefore, good project management software should support collaboration and should store information in a way that can be accessed at any time (Arnold & Javernick-Will, 2012; Assad & Wasil, 1986). Furthermore, one of the most important activities in managing a project is communicating information to key stakeholders. Stakeholders need information about what has been completed and what is planned, as well as what lessons learned in the process. However, not all project information needs to be accessible. So, the system needs to allow stakeholders to access some, but not all, of the information in the project. With the overarching pedagogical requirements of JBPM software established, a plan to develop the software was the next step to take.

Purpose II: Mapping the Technical Requirements of JBPM

To sidestep operating system issues (Windows versus OSX versus Linux) and of course delivery (online versus on-the-ground), it was decided very early that to provide consistent access to project workers and stakeholders, the software would be developed as a cloud application, making it platform-independent (Khan et al., 2012). An additional benefit of developing JBPM as a cloud-based application is that collaboration is inherent in the design of the system from the ground up.

From a design perspective, the foundation of a software system is its database. Understanding the nature of the information stored in a system will give one an indication of that system's capabilities. Rather than showing the code used to create the database, we created an entity relationship diagram, or ERD, which shows the structure of the database—the foundation upon which the software rests (see Figure 1). Detailed descriptions of these entities are included in the appendix.

In addition to the central database to support the capture of project information, JBPM also required an intuitive interface to reinforce project management concepts that students can navigate intuitively. Research in user acceptance has

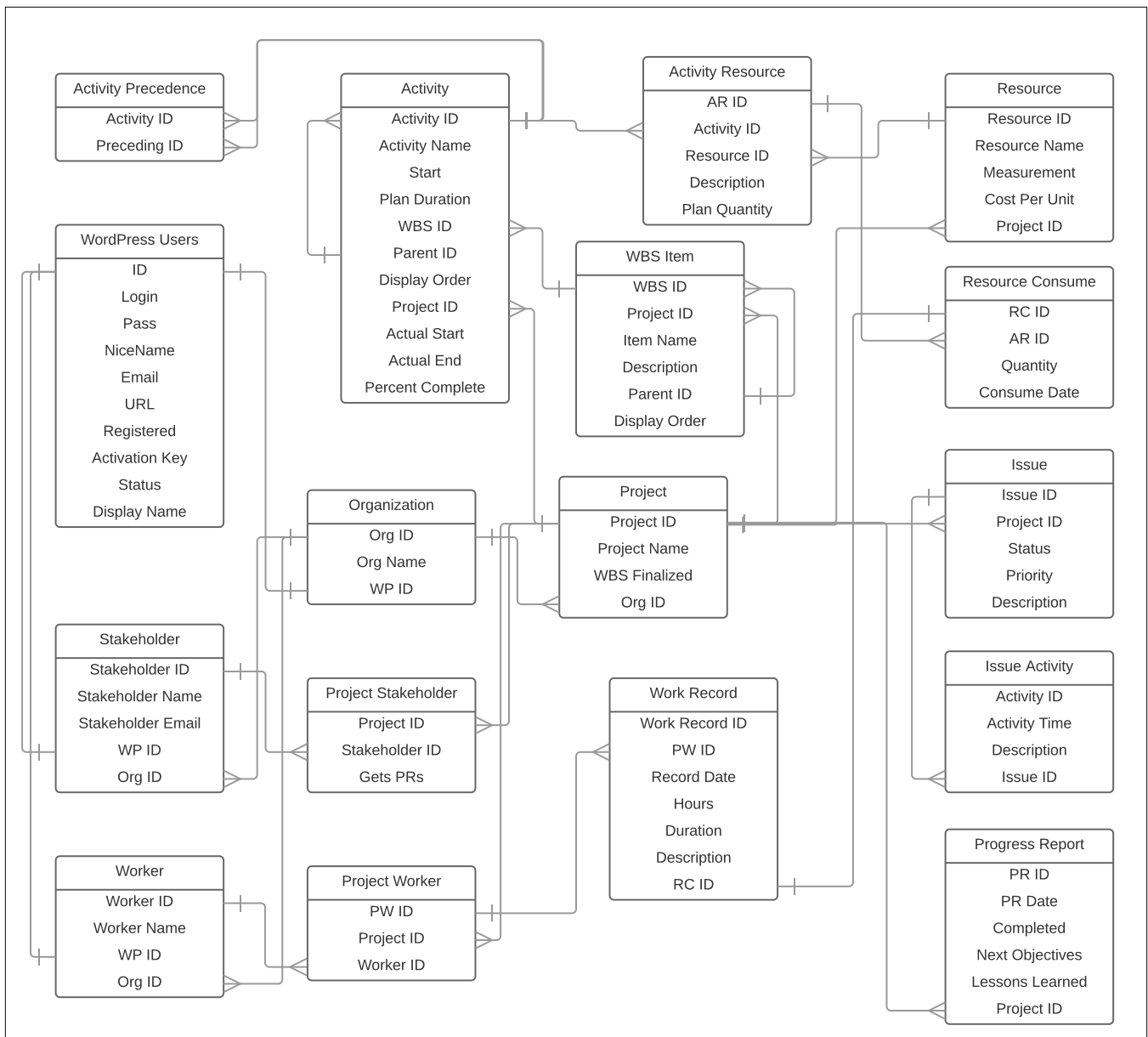


FIGURE 1. JBPM E-R diagram.

repeatedly shown that individuals prefer to use software that is easy to use and is useful (Davis, Bagozzi, & Warshaw, 1989). Finally, JBPM software uses open source software, including WordPress with HTML, CSS, Bootstrap, JavaScript, jQuery, PHP, and MySQL.

The choice about why to use these technology tools is a function of context. I teach a Web Application Development class to undergraduate students. The class has no prerequisites; therefore, I assume students will not have programming experience. For this reason, I prefer a tool that is easy for non-programmers to use - WordPress. WordPress was originally designed to be a blogging platform, but it has grown to be a widely used content management system (CMS). It is easy to use, and it is also easy to extend.

When I teach students how to use WordPress, I have them use the drag-and-drop tools to design pages, menus, and themes. Then I have them customize the look and feel of the display by editing the cascading style sheet (CSS) files. Finally, I have them embed custom data-driven functionality by creating new MySQL tables, as well as the PHP code to handle functionality. This is accomplished with a WordPress Plugin. making it relatively easy for students to add complex functionality without coding the entire application.

Because I was comfortable with the WordPress environment, I chose to use it to implement the project management software. From my work as a practitioner, I knew that selecting a tool I was comfortable with would be consistent with

decisions made in industry about which software/ hardware to use on projects.

THE PROCESS OF DESIGNING AND DEVELOPING JBPM

In the corporate world, the director of the project management office will visit a project manager and ask, "What is the status of the project?" The project manager replies, "It's going great, no troubles. I feel as if we're on budget and on schedule." The director then replies, "I don't care how you feel; prove to me where your project is." In this example, earned value is one way to prove the status of the project. This is one of the most fundamental lessons students need to learn in a project management class.

Pedagogical Issue Driving the Development of JBPM

Students have an assignment in the Web Application Development course whereby they must manage a real-world project. Made-up projects won't do because project management is all about managing uncertainty whereas made-up projects lack uncertainty. Even something as simple as planning and executing a backyard barbeque qualifies as a real-world project. Microsoft Project™ would be a perfectly fine tool to manage said barbeque, but students would not see the value in MS Project™. All too often students would complete the project and then open MS Project and retrofit the event into the software. Compounding this issue is that learning to use MS Project™ would be difficult and impede the goal of learning the underlying project management principles. This frustrated my students. The only viable option was to find a better tool; a tool that complemented the learning of the two fundamental goals of managing a project and being able to prove the project status with respect to time and budget. Given that none of the major project management software packages met the five requirements (see Table 1), a solution had to be custom built.

For the end user, the application needed to be compatible with any web browser, which meant sticking with mature, widely available technologies that WordPress and other browsers support (i.e., HTML, CSS, and JavaScript).

To handle database interactions between JBPM and WordPress, PHP was the tool of choice. MySQL was the database selected to store information,

and jQuery, a JavaScript library that automates many common JavaScript routines, saved developer time when writing common routines. All three tools are open source, fast, and efficient.

To handle the possibility someone on a mobile device wanted to view JBPM, Bootstrap was used to simplify mobile handling so that separate versions for all the mobile operating systems would not have to be written. Bootstrap also recognizes the size of the screen used to access the webpage and automatically resizes the content to the most effective display. This way, a separate application would not have to be written for smaller screens.

Recalling the list of five overarching criteria for a good project management software tools, JBPM was inherently designed to be a collaborative platform. Given the inherent restraints of a three-hour college course, the PMBOK was used to determine the most salient course content. From this, JBPM was designed to address those goals, fulfilling a design requirement that the project management tool support the most important project management functions.

JBPM development

After deciding the underlying technologies to drive JBPM, all that was left was to actually build it. The system had to be able to allow students to learn underlying project management concepts without being intrusive. The basic concepts that needed to be implemented included

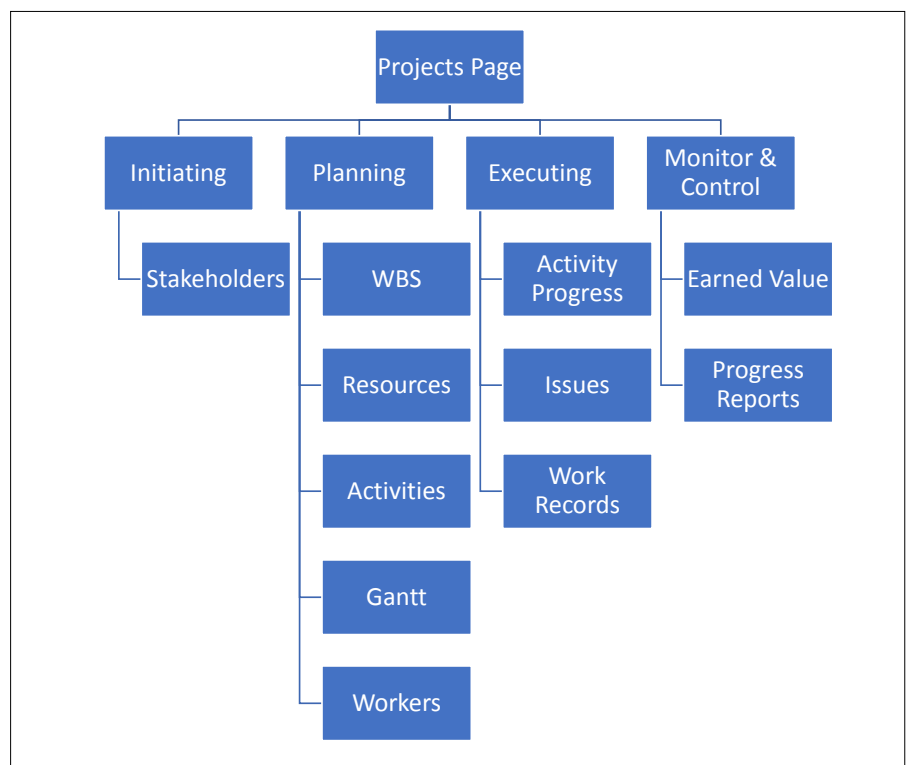


FIGURE 2. JBPM application hierarchical structure.

initiating, planning, executing, and monitoring. Additionally, when a project page was implemented, it allows the project manager to access the various projects. It works similarly to a table of contents in a book and isn't part of the underlying concepts students need to learn in a project management course. The hierarchical structure of the application is shown in Figure 2. The reason that items were organized this way is because it is consistent with the standards published in the PMBOK Guide.

The initiating tab has one option: the stakeholders page, which contains the list of key external stakeholders for the project. Stakeholders can receive automated emails from JBPM when a new progress report is created, if this option is selected.

In project management, one of the primary processes that should be done in every project is to define the scope. The tool commonly used for this process is the Work Breakdown Structure (WBS), which is a deliverable-oriented breakdown of the project (see Figure 3). The WBS is part of scope management and allows the project manager to show the project management office leader that the project meets scope requirements-no more and no less. The WBS must be finalized before activities can be defined. In this way, when activities are added, one can see which deliverables an activity supports.

The resources page is where all the information pertaining to the resources available to the project is stored. Resources can be labor, material, or equipment, and their unit of measure and cost is recorded on the resources page. This feeds the earned value reports that will be run later.

This is the contrary to the way MS Project™ is typically used. For example, when first started, the user is presented with a blank page to enter activities. This is why students often used project management software after the project was over, retrofitting their projects to the software. The WBS encourages the focus to be on deliverables, which are items that can be measured. Then the activities put the focus on resources, which constrain what is possible or not possible for a given project. It allows the project manager to know what is available for use and helps with the budget. To gently twist Peter Drucker's famous quote, "if you can't measure it; you can't improve it" - JBPM is designed to support the notion that if you can't measure it; you can't manage it. It does this by getting users to think about the end result and working back to the beginning. This refers to the notion of multiple paths as identified by Campbell (1989). Think of a game of chess. The goal is clear: to capture the opponent's king. How does one go about doing this? Performing a little math shows that after each player has moved chess pieces four times, there are over 288 billion different movement configurations on the chessboard. It makes sense to work

FIGURE 3. WBS page displaying the scope of the project.

backwards to the beginning, something MS Project™ isn't obviously set up to do.

Once the WBS is defined and resources are entered, only then can activities be entered into JBPM. Project activities are the means by which deliverables are produced. Therefore, each activity is related to a WBS item. Time and cost must be estimated for each activity. To assist with the time estimates, functionality for activity precedence and dependencies were built into the system. When precedence relationships are defined, start times update automatically for following activities. This allows the project manager to assess whether the project is on time. Cost estimates are handled through assigning resources to activities.

This is why the WBS and resources have to be defined before activities are entered into JBPM.

Once the activities are defined and the interdependencies among them mapped, a Gantt chart can be displayed. A Gantt chart is a list of activities, usually plotted on the Y-axis in reference to time, which often is plotted on the X-axis. The chart provides a visual overview of the project and how

much time each activity will consume, as well as an estimated completion date for the project.

The workers page shows human resources or workers available to a project. A worker is just a special type of resource. Workers also are allowed to access JBPM and collaborate on the project, but they must be identified before any work records can be created.

These five pages are implemented to help plan a project. Once planned, the project must be executed and monitored. Thinking back to how a project manager can show their boss exactly where the project stands, the page functions indicate where this occurs. In JBPM these functions are found in the Executing and Monitoring and Controlling tabs.

The activities progress page is where the project manager enters the appropriate time and cost information so that the earned value information is correct. Progress on project objectives is entered as percent complete for each activity. Cost information is tracked by entering quantities of resources consumed for each activity. Figure 4 shows how this is presented in JBPM.

WBS ITEM	ACTIVITY	ACTUAL START	ACTUAL END	COMPLETE	ACTUAL COST	
1 Pony Express						
1.1 Basic User Requirements						
	1.1.1 Create User Requirements		2016-10-27	100	\$0.00	Edit Resources Complete Activity
1.2 Functioning Website						
1.2.1 Development Environment						
	1.2.1.1 Create Development Environment		2016-10-27	100	\$195.00	Edit Resources Complete Activity
1.2.2 Final Website Development						
	1.2.2.1 Develop Website		2016-12-15	100	\$262.50	Edit Resources Complete Activity
1.2.3 Live Website						
	1.2.3.1 GO LIVE		2016-12-15	100	\$0.00	Edit Resources Complete Activity
1.3 Oversight						
	1.3.1 Manage Project		2016-12-15	100	\$135.00	Edit Resources Complete Activity

FIGURE 4. Activity progress page displaying progress on project objectives.

JBPM Project Management		Projects	Initiating ▾	Planning ▾	Executing ▾	Monitoring and Controlling ▾		
Project Earned Value								
ACTIVITY	PERCENT COMPLETE	EARNED VALUE	ACTUAL COST	PLANNED VALUE	COST VARIANCE	SCHEDULE VARIANCE	COST PERFORMANCE INDEX	SCHEDULE PERFORMANCE INDEX
1.1.1 Create User Requirements	100	\$45.00	\$0.00	\$45.00	\$45.00	\$0.00	0.00	1.00
1.2.1.1 Create Development Environment	100	\$45.00	\$195.00	\$45.00	-\$150.00	\$0.00	0.23	1.00
1.2.2.1 Develop Website	100	\$1,125.00	\$262.50	\$1,125.00	\$862.50	\$0.00	4.29	1.00
1.2.3.1 GO LIVE	100	\$135.00	\$0.00	\$135.00	\$135.00	\$0.00	0.00	1.00
1.3.1 Manage Project	100	\$1,500.00	\$135.00	\$1,500.00	\$1,365.00	\$0.00	11.11	1.00
TOTALS	100	\$2,850.00	\$592.50	\$2,850.00	\$2,257.50	\$0.00	4.81	1.00

FIGURE 5. Earned value page displaying the quantitative measurements of project schedule and budget.

Project management is about managing uncertainty. No matter how well a project might be managed, there always will be uncertainty, which brings issues that need to be addressed. Issues arise when working through a project, and it is useful to document and update information about the issues in a place accessible to all workers. Each time something happens related to an issue, a worker can input an activity record to document the updated information. Issues that are captured and stored allow an organization to learn because once an issue is identified and resolved, if a similar issue arises, a solution is readily available in the issues register.

The purpose of the works records page is twofold. First, it tracks the actual work being done on the project. Second, entries on the page create records from resources being consumed. The information captured on this page is critical to the proper calculation of project earned value.

The earned value page (see Figure 5) is arguably the most important page of JBPM. Here is where the project manager proves to the director of the project management office where the project stands. It contains information on costs, resource utilization, and variances from expected values.

The final screen of JBPM is the progress reports page and is used for managing a project. It gives a chronological view of the progress reports for a given project. Under the Monitoring and Controlling tab of JBPM three additional screens are shown. These include the report-activity,

report-logins, and report-work hours. All three screens allow the professor to monitor how students are doing on their project assignments. These reports do not contribute to managing a project, only to managing the project management course.

JBPM IMPLEMENTATION

Now that JBPM was a functioning piece of software, it was time to use it in a project management course. JBPM was used in both graduate and undergraduate courses. Furthermore, these courses are not taught using the exact same content. These courses also are offered both face-to-face and online. This section details the use of JBPM in these classes, and the impact JBPM software had on student learning. The section concludes with a discussion of the reflections on the design, which involved 47 graduate and 90 undergraduate students who used JBPM software.

JBPM Makes its Course Debut

When JBPM 1.0 was ready for use in a project management course, students were given the option to use JBPM or Microsoft Project™, which students have free access to via Microsoft Imagine. In the first semester, 61 students were able to use either system as part of their coursework. Most students chose JBPM over Microsoft Project™, which could possibly be because JBPM runs in a browser and, unlike Microsoft Project™, does not require the installation of additional software.

JBPM was designed to be easy-to-use and supports the most important project management functions; however, until student users confirm such claims, it cannot be determined if the overarching design criteria had been achieved. Users determine the utility of a design (Smith, 2010). Thus, a random sample of students (N=18) was gathered. These students completed an anonymous survey about JBPM, its ease of use and how it complements the conceptual material of the course. The items in the survey were drawn from the literature on technology acceptance. Perceptual measures have been used in this line of research for over 30 years. Perceptual measures capture the individual differences among people far more effectively than objective measures (what one person perceives as easy, another might perceive as difficult).

When asked about the user experience with JBPM, the sample of students overwhelmingly found it to be a positive experience. Regarding whether JBPM is easy to use despite a steep learning curve, two thirds (66.7%) strongly agreed. Furthermore, 50% agreed and 44.4% strongly agreed that it facilitated team collaboration, which totals to a 94.4% agreement.

JBPM Student Impact

The same survey also asked students about the impact JBPM had on learning of course concepts. One of the fundamental goals of the course is to make sure students can perform an earned value analysis of a project. According to PMBOK standards, capturing the proper work breakdown structure is critical to calculating earned value. JBPM Two-thirds of respondents strongly agreed that JBPM contributed to their understanding of earned value analysis and WBS JBPM.

Understanding earned value analysis and WBS is fine, but the whole purpose of JBPM is to help students learn the underlying project management concepts. That is, the tool does not get in the way of learning the concepts, but instead enables learning the concepts. Regarding whether JBPM contributed to their understanding of project management concepts and methods. 50% of the respondents strongly agreed that JBPM helped them to better understand project management concepts, and 55.6% strongly agreed that JBPM helped them to better understand project management methods.

Once students move beyond the course and into the workforce, they might be required to use project management tools that they deemed unsuitable for use in their course. This shouldn't be a problem since JBPM was designed to facilitate the learning of core project management concepts. One cannot learn all the intricacies of MS Project™ or Primavera™ in a single semester; however, once armed with the knowledge of how to properly manage a project, similar commercial software can be learned. Perhaps, because JBPM is open sourced, my students could introduce JBPM to their own workplace.

JBPM DESIGN FAILURES

Version 1.0 of JBPM was not perfect. While it did fulfill all five requirements set forth at the beginning of the project, other functionality needed to be added for subsequent versions of JBPM. During the development of JBPM, it was explicitly decided that users would not be allowed to delete anything that had been entered into the system. The primary users were students undergoing their first exposure to project management methodologies, and new users do not have a full understanding of the intricacies of how WBS works with scheduling, resources, and costs associated with projects. To prevent a novice from inadvertently deleting something critical, a delete function simply was not programmed into JBPM. This decision to prevent deletions quickly became an issue. Novices make mistakes and they need to be able to correct their mistakes. Subsequent versions will include delete functionality, and additional steps will be taken to prevent users from inadvertently deleting something critical.

The other reflections on design from Version 1.0 had to do with administering JBPM. At initial release, the professor administering the system had to add student users manually. Having to create upwards of 90 new users a semester was not a good use of the professor's time. Subsequent versions will allow the students to register themselves in JBPM.

JBPM MOVES BEYOND THE CLASSROOM

Students, particularly MBA students, appreciate real world examples. This is the attraction that many MBA students have toward business cases. Real-world success stories provide legitimacy that just cannot be achieved any other way. To provide real-world credibility, one of the authors used JBPM in his outside consulting practice.

For example, a local medical firm wanted to switch software systems and invited one of the authors as a consultant to manage this process, and the JBPM was used. The firm had hired an external vendor to do the switch over, but relations between the firm and the vendor became strained. Neither could effectively communicate with the other. The consultant used JBPM to manage communications between the stakeholders, tracking project activities and ongoing issues. Using the JBPM prevented many issues from falling through the cracks that would have strained the firm and vendor relationship further, and the project was successfully completed.

In addition, the JBPM was shared with a local chapter of the Project Management Institute (PMI). The goal was to encourage project managers to manage actual projects and make suggestions to increase functionality. Although the feedback from the local PMI chapter was uniformly positive, participants did suggest subsequent JBPM versions support milestones, risk management, and resource management. They also suggested that JBPM support aggregate resource utilization over several projects. The important thing to note

is that every suggestion these project managers made were for features that were beyond the scope of a first project management course.

JBPM NEXT STEPS

A design must be useful. JBPM 1.0 was successfully used across two semesters, even though it had a few problems. As discussed above, the biggest problem with the software was the inability to delete things. Continued development into JBPM software will remedy the lack of a delete function. It will also include adding the additional features and functionality suggested by the members of a local PMI chapter. Based on the survey results from project management students and professional project managers, the suggestions for improvement were outside the scope of a first course in project management. It was deemed that Version 1.0 of JBPM is suited to supporting the teaching of an undergraduate or graduate first project management course. This means quite a bit of real world functionality was intentionally left out of JBPM. Version 2.0 of JBPM would retain the ease of use of version 1.0, but additional features could be used to teach an advanced project management course, or even run a real-world project.

As of the writing of this paper, version 2.0 is close to being complete. Several important improvements are included in an upcoming update. Users will be able to delete items that are not related in the system. There will be an interface to enter and update Project Charter information. Flexibility is being added to the scheduling functionality by allowing users to define non-work days in the project. Risk management and communication management add limited functionality. Finally, support for complex project management tools such as the Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT) are included. When the new functionalities are released and tested, the software should be improved significantly.

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APPENDIX A

Detailed Description of Database Entities

ENTITY	DESCRIPTION
PROJECT	This is the central entity to which all others are linked. It does not store much information, but it keeps everything in the system organized. The only attribute that is displayed is the Project Name. The WBSFinalized attribute is a true/ false value that stores whether or not the work breakdown structure is locked for the project. To keep the work breakdown structure and activity list consistent, the software does not allow changes in the work breakdown structure after beginning the activity list. In the future, formal change processes will be implemented to allow for these types of changes. The Org ID attribute links the Project table to the Organization table. Users specified as organizations are the only users who can create projects. Each organization can create multiple projects.
ORGANIZATION	This entity stores information about users specified as organizations. Organizations are the only types of users who can create projects, add workers, and add stakeholders.
STAKEHOLDER	This entity stores information about users specified as stakeholders. This is not a comprehensive list of all stakeholders on a project. It is used to give key external stakeholders access to progress reports within the system.
PROJECT STAKEHOLDER	This is an associative entity linking Project with Stakeholder. It is needed because each stakeholder can participate in multiple projects, and each project can have multiple stakeholders.
WORKER	This entity stores information about users specified as workers. Workers can access most of the system. The only functions they cannot access are creating projects, adding stakeholder, and adding workers.
PROJECT WORKER	This is an associative entity linking Project with Worker. It is needed because each worker can participate in multiple projects, and each project can have multiple workers.
WORK RECORD	This entity stores information about actual work that is expended on the project. Workers can enter the date on which the work was done, the times of the day, the total duration of work for the day, and a short description of what was done. When a work record is entered, the system creates an entry in the resource consume entity to track project costs to be used in earned value analysis.
WORDPRESS USERS	Because the application is embedded within WordPress, user administration is handled by the WordPress Core. However, it is necessary to access this information so that users can be linked appropriately with projects.
PROGRESS REPORT	This entity stores information about progress on a project. The primary audience for a progress report is key external stakeholders. For simplicity, the table has few fields, but each field can store large amounts of data. The specific information that is stored for each progress report is the date, objectives completed, planned work, and lessons learned.
WBS ITEM	This entity stores items for project work breakdown structures. Because there can be multiple levels of items, the Parent ID field is used to support the structure. Each item also has a name, description, and display order.
ACTIVITY	This entity stores information about project activities. Activities are the means by which actual work is done. Activities can be broken down into smaller components, which is accomplished by the Parent ID field. At the highest level every activity is a subcomponent of a deliverable (WBS Item). This is because activities are the means by which deliverables are produced. Activities consume time and cost; therefore, they have planned start dates, planned durations, and they are related to resources (cost). For monitoring activities, it is necessary to keep track of actual start dates, actual end dates, and percent complete. Finally, to support the Gantt chart functionality, activity precedence is recorded.
ACTIVITY PRECEDENCE	This is an associative entity representing the many-to-many relationship between Activity and itself. Each activity can be preceded by multiple activities, and each activity can precede multiple activities.

ENTITY	DESCRIPTION
RESOURCE	This entity stores information about resources that consume cost on a project. Resources can be labor, materials, or equipment. To properly plan resource use, measurement (for example, labor hours, machine hours, units, etc.) and cost per unit are needed.
ACTIVITY RESOURCE	This entity is the associative entity between Activity and Resource. It supports planning specific resource amounts for each activity.
RESOURCE CONSUME	This entity stores information about how resources are actually used on a project, as opposed to how they are planned to be used.
ISSUE	During project work, issues come up that need to be addressed. This entity stores information about such issues.
ISSUE ACTIVITY	When addressing issues, it is important to record what was done and why so that all workers know the status. It is also useful for understanding why decisions were made after a project is completed.