KEYWORDS project management education project value strategic project management tactical project management

ABSTRACT

Modern project management approaches focus on maximizing the value realized from projects; yet, many project management textbooks and courses do not incorporate this aspect into their curriculum. This paper reports on our experience in developing and teaching project management courses that integrate the element of maximizing project value in their syllabi. The suggested teaching approach uses traditional and innovative models to teach students how strategic and tactical project decisions should be made. Students are introduced to models that support strategic decisions such as matching a project objective to a business case, deciding on a product configuration, and developing a project plan. They also learn about tactical decisions such as ones that are made during a project's execution and control, which are also important for realizing all the project benefits. Thereafter, students use an innovative model that links strategic and tactical decisions, implemented in a simulation tool, to experience the various tradeoffs that affect project value. Based on teachers' and students' evaluations, we recommend using the suggested approach in project management education.

INTEGRATING TRADITIONAL AND INNOVATIVE VALUE-FOCUSED MODELS IN PROJECT MANAGEMENT TEACHING

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INTRODUCTION

Modern project management approaches such as the increasingly popular Lean Project Management *(hereafter, Lean; Womack and Jones, 2010; Ballard and Howell, 2003)*, and Benefit Management *(Zwikael and Smyrk, 2011)* aspire to maximize a project's value to its stakeholders *(hereafter the term value is also used as synonymous to benefit)*. Still, project management education mostly relies on traditional models *(e.g., the critical path method and resource constrained project scheduling)*, which only consider time and cost aspects, without taking performance and value into consideration.

Value management focuses on strategic decisions such as defining a project objective, selecting a product configuration, and preparing a project plan. Serrador and Turner *(2014)* found that while meeting time and cost goals is important for project success, there are other important factors contributing to project success, presumably, project value.

The literature about value management is traced back to Slevin and Pinto *(1987)*. Based on 418 projects, they composed a list of 10 success factors that were classified into one of two classes: strategic and tactical. Strategic factors, such as defining the project objective and goals, getting management support and preparing the project plan *(all important components of value management, Zwikael and Smyrk, 2011 pp. 181)*, should be pursued in the project's early stages. The remaining seven factors are tactical and pertain to the ability to carry out the project according to its plan; they are mostly relevant during the project's execution. The authors found that strategic factors are more important than tactical ones, especially during early project stages, after which the importance of tactical factors increases.

Samset *(2009)* strengthened the conclusions of Slevin and Pinto *(1987)* about the increased importance of strategic decisions compared to tactical decisions by analyzing an on-shore torpedo battery building project that was completed as planned *(i.e., project execution was successful)* but closed soon after since it was obvious that the concept of stationary torpedo batteries is obsolete, and no enemy would expose its forces to these batteries—thus the project will never generate value. Clearly, the torpedo battery project closed because its owners thought that there is no linkage between what they perceive as value and the actual output. The decision making process that selected the stationary battery configuration, if performed, was deficient. Nelson *(2005)* denoted such a situation a "failed success".

The present article uses recent work that suggests improvements to project management education *(e.g., Vanhoucke, 2014)* as a starting point. The focus of our teaching approach is on maximizing a project's value, thereby bringing it in line with modern project management approaches.

A desired teaching approach is one that will lead to good strategic and tactical decisions in future projects. Yet, what constitutes a good decision? Furthermore, how can we teach our students to make such decisions *(see the discussion in Cohen, 2008, pp. 101-102)*? One answer is to examine a decision's outcomes, but such an answer is too simplistic in the context of teaching since it provides answers only in hindsight. Moreover, a decision that generates good outcomes after a year can lead to poor outcomes after five years, and a decision could lead to good outcomes only under specific realization of future events or to poor outcomes, through no fault of the decision maker *(Clemen, 1996, pp. 3-10)*.

Consequently, we follow Cohen *(2008)* who argued that the quality of the decision making process is a primary parameter in determining if a decision is good. In the context of teaching for successful project management, this means a focus on teaching high quality, formal strategic and tactical decision making procedures. This focus is in line with the link, established in value management literature, between formal processes and project success *(Serra and Kunc, 2014; Chih and Zwikael, 2014, Doherty et al., 2012)*. Specifically, we combine in-depth theoretical teaching of models with Simulation-Based Training *(SBT)* through which students gain experience using these models.

The suggested teaching approach has two distinct characteristics that make it attractive when teaching how

1. Introduction: What is a project?
2. An overview of traditional project management
3. Project scope
4. Defining project activities
5. Time, resources and cost estimation approaches
6. Network diagrams
7. Planning the schedule and cost
8. Project execution: Managing the project team
9. Project control
10. The critical chain project management
11. Project closure

TABLE 1. *A typical syllabus for a project management course*

to integrate project management and value management:

1. It focuses on models that link early, strategic decisions such as defining project objectives, identifying value, and defining target outcomes to project execution and control; the emphasis on this linkage is expected to increase the chance of realizing the project's value.
2. It combines theoretical models with SBT, which is an effective combination according to a recent study by Zwikael et al. (2013). They concluded that having adequate theoretical knowledge is a pre-condition for effective SBT of project management.

Differently from modern project management methodologies that use qualitative techniques for value maximization *(e.g., Lean; see, Womack and Jones, 2010)*, we use a quantitative model, introduced by Balouka et al. *(2014)* and Cohen and Iluz *(2014)*, which integrates decisions about product technical performance with time, cost and resource management decisions.

The suggested approach closes a lacuna in project management education resulting from the lack of focus on value management. The authors of the present paper who teaches in an institute of higher education has seen this common flaw in the courses taught to undergraduate and graduate engineering students. Only recently did we realize that it is important to emphasize value management issues in our courses and now have begun to do so.

3. Project Management Courses

This section provides a high level view of value management integration within project management courses, such as the ones taught in my department. Such a course typically includes 13 three-hour classes, each followed by a one-hour tutorial and home assignments.

Project Management Courses and Value Management

Through an Internet search, using terms such as "project management course", and "syllabus", I was able to explore project management courses around the globe in order to get an impression how value management is integrated in them. Many courses follow the PMBOK, which has yet to include value management, while other courses use various project management textbooks.

The courses are diverse in context *(e.g., software oriented vs. construction oriented)* but the terms 'value' and 'benefit' are rarely mentioned. Moreover, while some courses mention the project initiation phase—where value management plays a major role—many courses focus on scope, schedule, and cost without linking them to the project objectives *(see a typical syllabus in* **Table 1***)*. Even in courses that do refer to an initiation phase, we did not see evidence of value management oriented processes for identifying stakeholders and their needs, and transforming the needs into a specification and value.

Teaching in most courses is based on lectures and class discussions. Few courses use project management tools such as Microsoft Project to demonstrate technical issues *(e.g., how to construct a Gantt chart)*, and SBT is rarely used.

4. Suggested Course Structure

Table 2 presents a course structure that reflects the suggested teaching approach. Value management is stressed the most during the first third of the

Class	Topic Learned	Value management related HW/ Recitation/Simulation	Specific relations to benefit management
1	Introduction		Life cycle models, benefit creation purpose of projects
2-4	Project initiation and selection	+	Stakeholder identification, QFD (The House of Quality, The Voice of the Customer), identification of needs, cost–benefit and cost–effectiveness analyses, development and selection of alternatives, AHP, MAUT
5-6	Project scoping, work break down, and network models	+	The relation of scope to project target outcomes
7-8	Project scheduling		
8-9	Resource constrained project management	+	The effects of scarce resources on realizing project outputs
9	Project budget, project and product control		Control as a means to achieve outcomes
10	An integrative mathematical programming model	+	The relation between project outcomes, project cost, schedule and resources
11	A simulation exercise		In-class, 3-hour exercise in which students apply their theoretical knowledge in a simulator
12	Risk management	+	In-class simulation to demonstrate the impact of uncertainty and its effect on projects
13	Additional project management approaches, debriefing and summary	+	Lessons learned on how the improved project benefit are realized, other methodologies that emphasize value (e.g., Lean Project Management)

TABLE 2. *The focus on value management within a project management course*

course, when we teach front-end processes. For example, we teach students about project life cycle models such as the U.S. DOD 5000 and the six-phase life cycle model *(suggested by Archibald et al., 2012)*, which emphasize that project outputs should be utilized in order to realize overall project values. We also introduce models *(e.g., Quality Function Deployment—QFD, Analytic Hierarchy Process—AHP and Multi-Attribute Utility Theory—MAUT)*, which increase the chances that project outputs will be utilized by stakeholders. The students' apply the taught models to strengthen their theoretical models *(see an example in the appendix)* and use basic simulations. Next, we teach project management basics such as network models, scheduling etc. These foundations are important to realize project goals.

In the last third of the course, the students have sufficient knowledge to integrate value management into project management. At this point of the course, we teach an integrative mathematical programming model that links project strategic decisions such as choosing a product configuration with tactical scheduling and resource allocation decisions *(see Section 3)*, followed by an extensive, in-class simulation exercise such as the one described in Section 4.

5. The Taught Models

To generate value, project outputs must be used by stakeholders, which is why we teach models that emphasize stakeholders' involvement, especially in the first stages of the projects. This section describes the main models taught in the course and their linkage to value management.

The first model that we present to students is the Quality Function Deployment *(QFD)*, and especially its main design tool—the House of Quality *(Akao, 1997)*. The essence of QFD is to map stakeholders' needs through the so-called voice of the customer *(e.g., a need may be an economical car)*, to set attributes through which one can measure to what extent the need is fulfilled by a project or an alternative *(e.g., fuel consumption per kilometer)* and to set target outcomes which constitute the project value, if met *(e.g., 20% decrease in fuel cost per mile)*. Then, QFD defines requirements for these attributes, which form a product *(or service)* specification for outputs *(e.g., an engine volume of 1000 cubic centimeters)*. The important issue, which makes QFD adjusted with our value management focus, is that the specification *(i.e., project output)* maintains a close linkage to the project value *(Love et al., 1998)*. The House of Quality, which inherently includes a benchmark of products/services, enables the setting of realistic yet challenging target outcomes, which are required in order to improve performance. The link between setting challenging targets and improved performance has been demonstrated in general decision making settings *(e.g., Locke and Latham, 1990)* as well as in the context of project management *(Cohen and Iluz, 2014)*. We teach various approaches to combining QFD with other approaches such as Analytical Hierarchy Process *(AHP; Kwong and Bai, 2002; De Felice and Petrillo, 2011).*

AHP was introduced by Saaty *(for more details, see Saaty, 1988).* It is a decision making approach for prioritizing and selecting attributes and alternatives in complex, multi-attribute settings with various stakeholders. In our context, AHP gets as inputs the outcome attributes *(e.g., through QFD)* and calculates their relative importance *(weights)*, which allows them to be prioritized *(e.g., when there are tradeoffs between competing outcomes; see Zwikael and Smyrk, 2012 pp. S14).* When defining alternative project concepts *(e.g., investing in a stationary torpedo battery or in a fleet of torpedo equipped ships)* and configurations *(e.g., reengineering a torpedo or developing a new one)*, the attributes are scored on how well they are satisfied by each alternative *(e.g., to what extent the selection of a configuration satisfies the target outcomes).* This allows one to calculate a value for each alternative, based on the weighted summation of the scores. These values enable us to discriminate between the outcomes of possible alternatives, thus aiding in selecting the best one.

As an alternative to AHP, we teach Multi-Attribute Utility Theory *(MAUT, see Sarin, 2013)*, which is specifically designed to maximize the utility *(i.e., value)* in complex decision making settings while taking into account personality characteristics or organizational culture *(e.g., risk averseness)* and the specific situation *(e.g., the stakes at risk and the level of uncertainty).* As in AHP, the first step is to decide on attributes and outcomes. For example, valid attributes for a project that aims to develop a non-petroleum car with a primary objective to reduce the yearly family expenditure are the operating cost per kilometer and the car's reliability; possible target outcomes are a 20% reduction in the cost per kilometer, and a 25% increase in the intervals between maintenance checks. MAUT assumes that a real valued function can represent the decision maker's preference ordering, so the next step is to construct the decision maker's utility function with regard to the attributes and to evaluate how they are met by different project concepts *(e.g., an electric car vs. a solar car)* or by different configurations *(e.g., using current battery technology in an electric car or designing improved batteries based on new technologies).* Then, the multi-attribute utility function value is calculated, through a structured process—which we teach in detail—enabling outcome maximization decisions regarding concepts and configurations.

Finally, we introduce to the students a new mathematical programming model that maximizes the project value, subject to constraints such as meeting a due date and a given budget, maintaining a positive cash flow throughout the project, satisfying resource availabilities, etc. What is innovative about this quantitative model is that it accommodates the impact of both strategic and tactical decisions—both of which are important for a project's success *(Serrador and Turner, 2014; Serra and Kunc, 2014).* The model is flexible in the sense that tactical aspects such as meeting cost and schedule goals can be included in the objective function to reflect the relative importance of these goals compared to achieving target outcomes. Thus, the model, introduced by Balouka et al. *(2014)* and Cohen and Iluz *(2014)*, finds *(near)* optimal project configurations and plans with respect to a given objective function and the associated project schedule and resource management policy *(that is, how many resources to reserve for hiring/firing throughout the project).* This NP-hard model must be solved via heuristic approaches. A simplified version of the model with a solution algorithm was implemented in a simulation tool, so that our students could use it. The model can also be used for project control; if the project deviates from its plan, the model can be resolved with updated data, to yield recommendations for plan adaptations.

Finally, we teach students the concept of an efficient frontier. In real projects there are numerous possible project plans and product configurations, but only a fraction of them—those that are both feasible and expected to deliver the target outcomes—should be considered. To this end, we teach students to construct and analyze an efficient frontier, which only contains these viable plans, delivering the highest outcome for a given cost. In contrast, any project plan with an equivalent or lower outcome that costs more is not efficient and should not be considered. Students learn that they should choose a plan on the efficient frontier—sometimes higher outcomes and higher cost plans are preferred and sometimes a small increase of the outcome does not justify a large additional capital expenditure.

To recapitulate, we teach several value focused models, for use in the project front-end and a mathematical programming model that feeds from these models and is used in the design, planning and execution phases of a project. Students apply the models in a simulated project environment, as described in the next section.

6. Simulation-Based Training

A project goal, its objective function, a product concept and a project plan, as well as execution related decisions, interact to determine a project's outputs, cost, schedule, etc. Insights regarding these interactions are hard to obtain, especially since the involved mathematical models are complex. In such circumstances, simulation-based training *(SBT)* is an appropriate tool for experiencing the interactions.

SBT has been recognized as an effective teaching approach *(e.g., Ruohomaki et al., 1995).* We mention in passing the extensive practice of SBT in various disciplines such as software engineering *(Pfahl et al., 2001)*, time-critical decision making *(Cohen, 2008)*, and flight training *(Rolfe and Staples, 1988).* Likewise, there are many project management simulators *(e.g., Celemi, Double Masters, Forio, Polstar, Race to Results, SimProject, SMG, and Synergest).* We use a simulator that was specifically developed to model the links among performance, cost and time aspects, as detailed next.

The Simulation Tool

The simulation tool—the PTB *(Shtub, 2012)*—facilitates a stochastic, dynamic project management training environment. It was developed to close a gap, found in previous simulators *(e.g., Davidovitch et al., 2008)*, that did not integrate PMBOK knowledge areas. PTB guides students through project management processes, such as choosing a project concept, planning, execution and control, and through knowledge areas, such as scope management, cost management, time management, quality management, risk management, etc. It does not require prior simulation knowledge, and students can learn to operate it within an hour, which made it ideally suited for our course.

PTB can simulate project scenarios with budget, schedule and performance constraints. Students can design project concepts, choose product configurations from those available, and analyze possible tradeoffs. For example, a student can choose an innovative high performance configuration *(e.g., a new technology based design)* that entails budget and schedule risks, or a conservative configuration *(e.g., a modification of an existing design from a previous project)* that may lead to lower performance and enjoys lower risk and smaller budget expenditures. Which choice will lead to the desired project outcomes? This is exactly the type of dilemmas we want students to grapple with, by applying the models they learn, using PTB.

PTB supports several project management best practices, which are learned in the course, for choosing among alternatives, for scheduling, budgeting, resource management and control.

The Simulation Concept

We detail here the characteristics of simulated project scenarios and the simulation concept. A good PTB scenario enables students to experience dilemmas that reflect what they will face in reality. Ideas for creating scenarios are detailed in Section 5.

We model a project as an Activity on Node *(AON)* network, where the nodes represent activities *(or work packages)* and the arcs are precedence constraints. Each activity may be performed in one or more modes. A mode can be viewed as a chosen alternative for an activity *(e.g., for the activity "design database configuration", two possible modes are: Design a centralized database or a decentralized database).* Each mode is characterized by output, cost, duration and resource requirements. The amount of resources, renewable and non-renewable, is limited and the project must maintain a positive cash position throughout its duration. The project may face different conditions such as an interest rate, a due date with bonus/penalty for earliness/tardiness, respectively, etc. The project management environment is uncertain, in the sense that actual project execution may deviate from the plan *(e.g., activity durations are random variables drawn from Beta distributions).* The project objective function is determined through procedures, discussed earlier, such as QFD, AHP or MAUT. An important feature of the model is that it links the activity outputs to the project's expected value. This is done by setting weights to the different outcome attributes and by the linkage that QFD *(and similar approaches)* establishes between output values *(i.e., those required by the specification)* and the corresponding outcomes.

Students have to consider alternative plans and configurations and choose an efficient one. The efficient frontier *(that includes the efficient alternatives)* is automatically generated by solving mathematical models via heuristic approaches *(e.g., a genetic algorithm).* After deciding on a

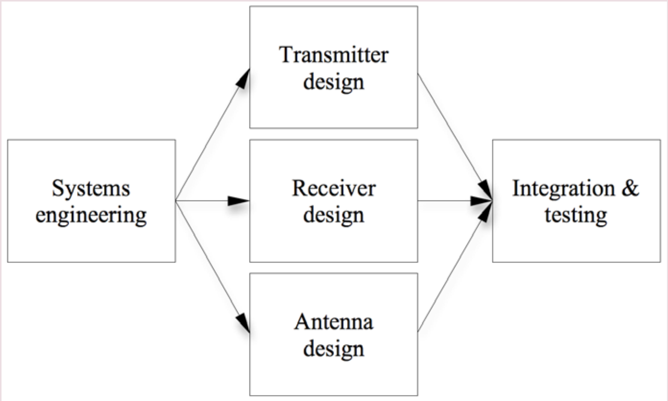
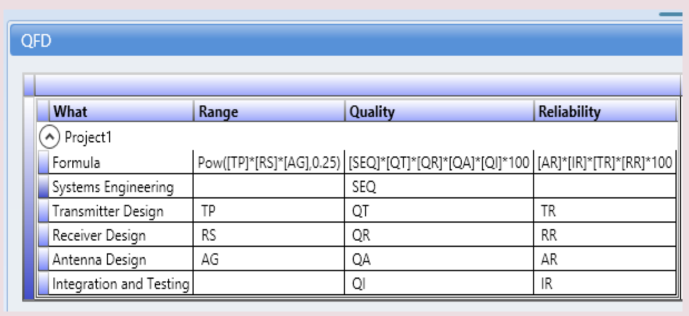


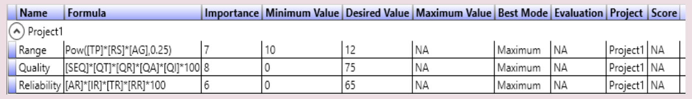
FIGURE 1. *AON for a radar development project.*



QFD

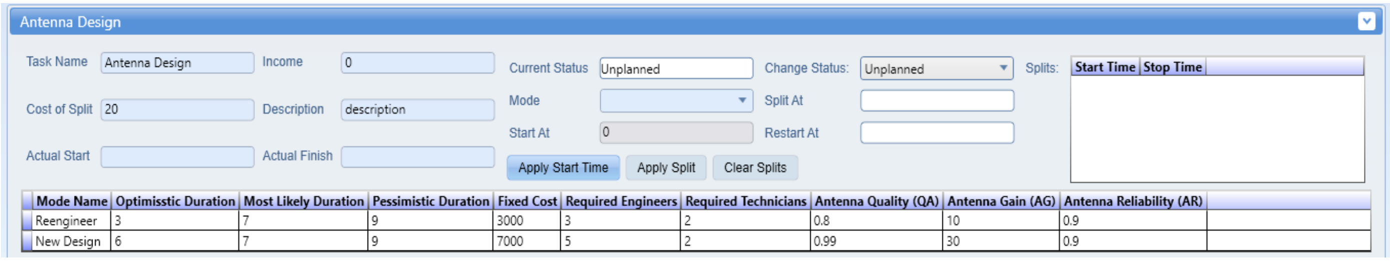
What	Range	Quality	Reliability
Project1			
Formula	Pow([TP]*[RS]*[AG],0.25)	[SEQ]*[QT]*[QR]*[QA]*[QI]*100	[AR]*[IR]*[TR]*[RR]*100
Systems Engineering		SEQ	
Transmitter Design	TP	QT	TR
Receiver Design	RS	QR	RR
Antenna Design	AG	QA	AR
Integration and Testing		QI	IR

FIGURE 2. *A PTB screen shot that presents the formulas and parameTers for calculation of the radar's quality, range and reliability.*



Name	Formula	Importance	Minimum Value	Desired Value	Maximum Value	Best Mode	Evaluation	Project	Score
Project1									
Range	Pow([TP]*[RS]*[AG],0.25)	7	10	12	NA	Maximum	NA	Project1	NA
Quality	[SEQ]*[QT]*[QR]*[QA]*[QI]*100	8	0	75	NA	Maximum	NA	Project1	NA
Reliability	[AR]*[IR]*[TR]*[RR]*100	6	0	65	NA	Maximum	NA	Project1	NA

FIGURE 3. *A PTB screen shot that presents relative importance of the radar's range, quality and reliability.*



Mode Name	Optimisstic Duration	Most Likely Duration	Pessimistic Duration	Fixed Cost	Required Engineers	Required Technicians	Antenna Quality (QA)	Antenna Gain (AG)	Antenna Reliability (AR)
Reengineer	3	7	9	3000	3	2	0.8	10	0.9
New Design	6	7	9	7000	5	2	0.99	30	0.9

FIGURE 4. *A PTB screen shot that presents the data for the activity "antenna design".*

project plan, its execution commences. Until the project is completed *(or abandoned)*, uncertainty plays a role in the scenario and students have to control and react to changes in the plan. When faced with time and cost overruns, students have to deal with the dilemma of what should be done to maximize the outcomes—continue without changes, change modes *(scope)*, and/or reschedule and change resource management policies. Upon completion, the project outcome, if utilized, is automatically calculated, and students' performances can be evaluated. In a debriefing session, which completes the project, the students assess their performance and gain insights into future projects.

FIGURE 5. *A PTB screen shot that presents the efficient solutions for the radar project.*

7. An Illustrative Example

A stylized example, such as the one described below, is typically given to students in the last part of the course.

Consider a radar improvement project, composed of five activities *(work packages)*, as presented in **Figure 1**.

The students use QFD to identify the required outcomes, which are defined as targets.

The radar project aims to improve identification of aerial threats, which was mapped to be a function of three attributes: The radar's range, its quality and reliability. The current baseline of the existing radars was evaluated, resulting in the following target outcomes. The radar's range should be increased by 20% *(i.e., 12 miles compared to the current 10-mile range)*. The target outcome for the quality was: Increased identification quality of objects 15% smaller than those identifiable by the current radars. The target outcome for reliability was: 10% increase in time between failures by 10%. We note that the realized value of each of these three attributes is affected by mode selections for project activities, as demonstrated in **Figure 2**. For example, outputs such as the transmitter power, receiver noise and antenna gain determine the radar range through the radar equation (**Figure 2**, *see the formula for range)*. Note that similar radar range values can be attained by different mode selection combinations *(each activity mode selection yields a different output)*. Nevertheless, these selections also affect the project risk, duration, and cost, and may yield tradeoffs with the other attributes—all these complex interactions have to be taken into account and may affect project outcomes.

To resolve possible tradeoffs, students carry out the procedures they have learned such as the House of Quality, AHP or MAUT, which provide the relative importance of the attributes, and their target values. Figure 3 presents the outcome of such a procedure. The formula for the expected outcome is: *7x[Range]+8x[Quality]+6x[Reliability]*, where target outcomes for each attribute have been set earlier. Having done all this, there is a basis to plan a project that will maximize the outcomes, subject to the project constraints.

In the simulation, each project activity is associated with modes from which one has to be chosen. For example, see the data for the activity "antenna design" in **Figure 4**. There are two possible modes: Reengineering the antenna currently used and designing a new antenna. For the former mode, the expected duration, costs and resource requirements are lower than for the latter mode, and the performance is also expected to be lower. Students have to consider the tradeoff between the two modes. When planning is completed, PTB provides students with relevant alerts *(for example, when resource requirements exceed their availability)*, and information about the project's expected completion date, cost, etc.

Obviously, in real projects there are numerous mode combinations of which only a handful can be thoroughly analyzed *(e.g., if there are n activities, with 2 modes for each, there are 2^n possible combinations)*. At this point in the simulation students are requested to analyze the efficient solutions *(i.e., the ones that constitute an efficient frontier)*, such as presented in **Figure 5** for the radar project. For this project, only two of the possible 2^5 combinations are determined to be feasible and efficient so students can focus their attention on them. By saying efficient, we mean that there is no other combination of modes for which the outcome is higher and the cost is lower.

Students have the option of overriding the efficient frontier recommendations and exploring other alternatives.

Finally, students choose a project plan and start the execution phase. When there are conflicts, such as in the case of a resource shortage, students have to deal with them through rescheduling, mode changes or resource management decisions. They are asked not to rely on intuition and to use the decision making models they have been taught.

Students may use saved simulation history to review the project, either in class, or individually. The PMBOK *(2013, pp. 99)* acknowledges the importance of such review for improving future projects.

8. Developing Project Scenarios

Project scenarios for the exercises should be prepared and validated carefully to increase SBT effectiveness *(Zwikael et al., 2013)*. Exploiting the full benefits of SBT is very dependent upon the developed scenarios, so a lot of attention should be invested in developing high-quality SBT scenarios. In this section, we briefly present two ideas, typically used in our scenarios, to emulate value-related dilemmas and tradeoffs.

The first idea is to design scenarios in which there are tradeoffs between a project's performance and its cost. The tradeoffs can take different forms. A classic tradeoff is one in which configurations with higher performance *(enabling higher outcomes)* lead to higher life cycle costs. Students need to decide if it is worthwhile, from a project outcome perspective, to choose the higher performance modes or to opt for lower performance to prevent budget overruns, project delays, etc. A popular strategy that captures such tradeoffs is benefit–cost that maximizes a project's benefit-to-cost ratio. Our experience suggests that students intuitively choose high performance modes *(that is, over-scoping)* and underestimate the effect of the resulting increased cost. SBT together with the use of the studied models are necessary to achieve high benefit-to-cost ratios in such scenarios *(Cohen and Iluz, 2014)* and teach students not to rely on their intuition.

Obviously, a project that leads to bankruptcy does not provide any value, and can pull down the company *(see Pan and Flynn, 2003)*. Thus, the second idea emphasizes the importance of scheduling, value and cash flows. To this end, we design projects with tight cash flows and multiple payment milestones. Upon the milestones' successful completion, the company receives payments, which may be used to finance future activities. Since the project cash flow is designed to be tight in the project's early stages, students who choose the more expensive modes can end up bankrupt. To reap the potential values from such projects, students have to make the correct choices of modes and schedule payment milestones, near their early starts.

9. Students' and Teachers' Perspectives about the Teaching Approach

This section provides qualitative perspectives by both teachers and students about the teaching approach. The teachers have been teaching project management courses for more than 10 years *(and have 20 years of experience in project management as workers, managers or consultants)*; the students are undergraduates and graduates who used the simulator.

The in-class feedback to the teachers led them to believe that SBT and value management integrated with conventional project management models increased students' understanding of the integrative nature of projects and the importance of jointly considering strategic and tactical decisions *(e.g., design decisions that directly affect the project outcomes and resource management decisions that affect project efficiency)*.

The teachers believe that the students gain insights into value-cost-time-performance interactions that if not for SBT, might not have been identified *(this belief was confirmed by analyzing students' feedback, as detailed below)*.

Students' assessment of SBT were collected, through questionnaires *(Coffani, 2013)* that were analyzed using statistical methods *(i.e., non-parametric tests such as Wilcoxon signed-rank, and Wilcoxon matched pairs)*, and qualitatively *(coding was the analysis method used)*. The feedback *(from 38 students)* indicated that PTB users think it is a good project management training tool and that it enhances the understanding of project tradeoffs, which is one of our main targets. Answers *(on a five-level Likert scale: 1=strongly negative,…,5=strongly positive)* to questions such as: How well do you understand the possible tradeoffs of your project *(Mean=4.0)*; and how simple is it to schedule a project for the first time *(Mean=4.1)*, supported good effectivity of PTB. In these aspects, PTB was found to be significantly more effective compared to the popular Microsoft Project software package, thus underscoring our use of SBT.

Roth *(2014)* analyzed PTB for functionality and then conducted experiments with 16 undergraduate students in their 4th and 5th semesters. He stated in his report that "The usefulness of the PTB software in university courses and PM courses along with the improvement of practical PM skills is approved. Additionally, the qualitative written and oral feedbacks were in the majority with some exceptions, in favor of PTB. Most of the negative statements were due to the experiment design especially the scenario choice and some introductory weaknesses. Therefore, these cannot be attributed to the software." His last two sentences are in line with the teachers' assessment, and with the relevant literature *(Zwikael et al., 2013)* that scenario development is very important.

10. Concluding Remarks

We suggest a teaching approach, which is consistent with new project management trends that focus on projects' values. This teaching approach, which incorporates traditional project management models, an innovative mathematical model and SBT, enables students to experience the impact that decisions regarding different project knowledge areas may have on a project's value.

Unlike conventional project management teaching approaches, the use of SBT provides real-time feedback regarding the students' performances, and offers opportunities to improve them. The feedback, from teachers and students, about the suggested approach are encouraging so we recommend considering its application in project management education.

APPENDIX — AN EXAMPLE OF AN EXERCISE FOR CHOOSING THE HIGHEST BENEFIT ALTERNATIVE

A car manufacturer wishes to improve the popularity of the next family car model compared to the current one. After conducting a survey among potential customers, the manufacturer identified the three main attributes that affect the current car's popularity: Fuel consumption, esthetics, and safety level. The manufacturer-defined target outcomes compared to the current situation: 15% improvement in fuel consumption, which in the current model is 13 KPL (kilometers per liter), 15% improvement in the assessment (by a group of designers) of the car's esthetics (now ranks 6 on a scale between 1-10), and a safety rating increase of 1 star (present ranking is 4 stars by NHTSA rating). However, there are tradeoffs between the target outcomes and the organization has to select the maximum value alternative from the three relevant alternatives, presented in the table below. Use MAUT to choose the best alternative.

#	Attribute	Alternative			Worse value	Current value	Best possible value
		3	2	1			
1	Fuel consumption	20	15	10	10	13	20
2	Esthetics	6	9	8	1	6	10
3	Safety ranking	5	4	5	1	4	5

Additional information about stakeholders' preferences with regard to the attributes:

1. Indifferent about fuel consumption of 15 KPL with certainty to 20 KPL with 50% probability and 10 KPL with 50% probability.
2. Indifferent about esthetics ranking of 6 with certainty to 10 with 60% probability and 3 with 40% probability.
3. Indifference between safety ranking of 4 with certainty to 5 with 90% probability and 3 with 10% probability.
4. The attributes are not additive independent and $k_1 = 0.3 \quad k_2 = 0.2 \quad k_3 = 0.5$.

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