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Design and Implementation of a Practice-Based Course in Contracting and Project Management

Ms. Kristen Caroline Hurtado, Arizona State University

Kristen Hurtado, MS, LEED AP (O+M), FMP, Fulbright Scholar, is a PhD student in Construction Management in the School of Sustainable Engineering and the Built Environment at Arizona State University (ASU). Currently, Kristen's research is in the fields of measurement of adult learning in the built environment and how that relates to organizational change management. She is a lecturer and project manager at the Performance Based Studies Research Group (PBSRG), at ASU. Kristen has her undergraduate and graduate degrees in Construction Management, with an emphasis on Facilities Management from ASU. In her career, she has had the opportunity to work in the building industry for large international contractors, owners, consulting entities, and recently as an educator in the field. She has seen projects in the public, private, transportation, health, and manufacturing sectors. While also pursuing her PhD, Kristen is also working towards another graduate degree in Education and Instructional Design.

Mr. Jake Smithwick, Arizona State University

Jake Smithwick is a Ph.D. Candidate in the Del E. Webb School of Construction at Arizona State University (ASU). He received his degrees in Computer Information Systems and Construction Management, and spent six years in the US Air Force (Civil Engineering / Emergency Management). Jake's research is focused on optimizing project delivery within construction organizations (owners, contractors, designers/engineers, and other entities) in value-based project delivery. He has supported over 115 projects totaling $573M of project value, in diverse scopes (new construction, tenant improvement, software services, health insurance, commodities, and others), at a wide range of public and private organizations

Prof. Kenneth Timothy Sullivan, Arizona State University
John Savicky, Arizona State University

John Savicky is a Lecturer and the Director of Sourcing Research at Arizona State University (ASU). He has worked with private, public, federal, and international organizations, procuring over 700 projects and services (worth over $1.5 Billion).

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Kristen C. Hurtado, Jake B. Smithwick, Kenneth T. Sullivan, and John Savicky
Arizona State University
School of Sustainable Engineering and the Built Environment

Addressing the needs of engineering curriculum to provide evidence-based practice and opportunities for students to gain skills that can be applied in the workplace has been identified as a need by industry and accreditation bodies. Institutions are seeking to properly meet these needs, while also balancing decades of history with traditional courses. Courses that teach business-type practices and fundamentals help fill key a necessity for the "engineer of the future." In response, the researchers developed a new course over two semesters that provides instruction on the owners' role in developing request for proposals (RFP), evaluating proposals, conducting project pre-planning, and identifying project performance indicators. The researchers used applied instructional design concepts from the field of education in creating the course, focusing on the objectives and related student outcomes. Thus, the primary goals of this paper are to summarize the researchers' course development efforts so that others may benefit in their own development of similar courses, and also, present some initial findings of student support and learning as a result of the course. Specifically, student enrollment in the course increased by 42 percent, students' final project quality increased by 20 percent, and students' self-efficacy ratings increased across all performance objectives by 109 percent. These results have encouraged the researchers to continue course refinement and work towards further instructional and assessment tools.

Keywords: business concepts, contracting, project management, scenario-based instruction

Introduction and Literature Review

The educational needs for the 21st century engineer have been outlined and lamented for not having been met in current curriculum for decades [1,2,10,3,8]. With current estimates that the industry will face a deficit of engineers to meet the demand due to upcoming retirements, a well-rounded engineer that is educated in technical and managerial skills will be best situated to meet these broad needs. Researchers are calling for a change in delivery, coupled with attention to education of the practical skills that future engineers will need in the workplace[2]. A survey of engineering professors in the USA found that 87 percent of professors use traditional lecture means by which information is transmitted to a passive student audience[2]. Increasingly, alternative instructional strategies are being explored for various subjects in construction management. While both technical and managerial skills are needed, instructors are faced with the challenge of meeting these needs while also managing their current teaching loads and developing new courses to address these gaps.

Graduates of construction management (CM) programs may find job placement in less "traditional" roles, which is an important consideration in education of CM students to prepare them for the industry. Construction management students may become project managers, design managers, procurement managers, owner representatives, and other roles[3,8]. With such a wide

variety of potential job functions, graduating students may find themselves unprepared based on current course offerings.

CM education has struggled to find a balance between technical and managerial content over the past few decades[11]. Much of the education has focused on issues relating to the contractor's perspective; very few courses provide insight on the owners' role and its impact on construction project delivery. This unbalance approach limits student opportunity for learning, and especially considering the varied roles CM graduates will one day work. Given the volatile nature of the construction industry, owners may choose to have more internal construction managerial staff and related job opportunities and reduce their outsourcing to external contractors.

Some suggestions have been to develop courses that are "transprofessional" in nature[3], to explore problem-based instruction[4], and to incorporate more leadership and business concepts into the curriculum[8]. To this end, the researchers developed a course in sourcing, contractor selection, and management was developed and tested across two semesters in a large university's construction management department. The course instructional design is shared to promote understanding of the differences in this course and to assist instructors in developing similar curriculum to meet the needs identified.

Course Development Methodology

The researchers used targeted instructional design methods from the field of education in an effort to intentionally fill a void in current curriculum offerings. The course was taught at a large public university in the CM department and was run as a cross-listed (undergraduate and graduate) elective course for the spring and fall 2015 semesters. The course met three hours once per week in the spring and 90 minutes twice per week in the fall.

The two semesters of the course were assessed and compared against typical education metrics: enrollment, final course project grade, and course rating. A less known metric, self-efficacy was also discovered and utilized in the second semester to further measure the effectiveness of this course. The metrics are used to measure the course design, current effectiveness of the course, and highlight areas for future improvements.

A "backwards design" approach was taken for the instructional design of this course, beginning with the desired outcomes or goals for what the learners would possess by the end of the course. The backwards design approach, while it appears to be common sense, is quite contrary to how courses are actually designed[8]. Backwards design begins with the end in mind and asks the following questions: Given a task to be accomplished, how do we get there? What kinds of lessons and practices are needed to master key performances? What would we accept as evidence that students have attained the desired understandings and proficiencies – before proceeding to plan teaching and learning experiences? The main phases of the backwards design process are: (1) identify desired results; (2) determine acceptable evidence; and (3) plan learning experiences and instruction[8].

Identifying desired results also involved laying out learning objectives that are both clear and worthwhile to the particular audience[7]. In the case of this course, the target audience was construction management students with less than five years of industry experience and are looking to better understanding the contracting process as it relates to Requests for Proposals

(RFPs). In order to accomplish this, students will need to have a clear understanding of the various parties that engage in the RFP process: clients/owners, procurement/purchasing, and contractors/service providers. From this perspective, nine performance objectives were outlined (Table 1).

Table 1 – Learning Objectives Paired with Class Activities

No.	Learning Objective	Activity #																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	Identify the sequence & types of sourcing strategies	X	X	X				X											
2	Identify the key criteria in scopes of work		X		X														
3	List the steps in Source Selection/Evaluation/RFP formulation					X	X			X	X	X							
4	Identify the steps in prioritizing proposals					X						X	X						
5	Identify the key elements in contract negotiations/pre-project planning													X	X				
6	Identify risk management practices																X		
7	Generate measures of contract value				X	X	X						X		X	X			
8	Recognize when information is represented in a clear, concise, & easily understood manner				X	X	X	X	X		X	X	X	X	X				X
9	Organize & represent data/research findings in a simple fashion									X			X			X	X	X	X

Identify the sequence & types of sourcing strategies – objective #1

Students are commonly familiar with the competencies and strategies of how to "do the work," but not how to "get the work." Sourcing is a key aspect of all organizations and students in the built environment will be on either side of sourcing equation at some point during their careers. In this section of the course, students gain insight into the actual steps of the sourcing process (i.e., identify the need, gather current constraints, create an RFP, lay out selection process, and other activities leading up to award of contract).

Identify the key criteria in scopes of work – objective #2

While some students may be familiar with the concept of "front end planning[5]" they may not have seen a scope before or tried to understand a specification. In this section, students will review actual scopes of work from a variety of project types, from simple to complex and across different industries (i.e. construction, services, IT, etc.) and evaluate their completeness, make suggestions for improvement, and even try to execute a scope of work (by building a LEGO car – see the next section for more details on this activity). Students will see the importance of

defining scope and the critical elements, gaining information on current problems/conditions, obtaining historical metrics/performance, setting and alignment of scope expectations internally, and generating accurate costing expectations.

List the steps in Source Selection/Evaluation/RFP formulation – objective #3
The source selection process encompasses a variety of activities and is covered both from the client/owner's perspective as well as the contractor/service provider's. This section includes activities that involve how to read and interpret an RFP to outline your response, organizing an RFP, leveraging contractor performance measurement, setting assumptions/expectations, setting evaluation criteria, the process of evaluating, creating Risk Assessment & Value Assessment Plans, performing interviews, and cost considerations.

Identify the steps in prioritizing proposals – objective #4
Once the evaluations are complete, the top contractor must be identified (as well as the other unsuccessful contractors). This section involves how to read and interpret the evaluation matrix, and conduct an appropriate vendor post-award debriefing. Industry examples and scenarios are utilized during activities.

Identify the key elements in contract negotiations/pre-project planning – objective #5
The time period before award of a contract is commonly overlooked in the overall planning process. In this section, students will learn about the importance of identifying areas of potential risk/red flags in costing and their proposal, and what are the characteristics of a "good" pre-project plan. Industry examples and documents are utilized in practice.

Identify risk management practices – objective #6
Upon award of a contract, issues during execution may arise and necessitate the reporting of identified risk, response, and measurements to mitigate the risk. This may also involve using previous project risks to improve current performance, incorporating similar risks into future projects, and determining how to proactively pre-plan to mitigate risks on future projects. A series of case studies from recent projects is also utilized.

Generate measures of contract value – objective #7
Owner/client evaluation of the true "value" or importance of the contractor and their services being provided is a common practice, yet less frequent area of instruction. Students will learn about the importance of a baseline and how to quantify the "value" of a project/service/etc. The various perspectives, such as the three pillars (i.e. time/money/satisfaction) and the executive-level perspective are shared. Students will see the importance of increasing accountability and transparency. A series of case studies from recent projects is also utilized.

Recognize when information is represented in a clear, concise, & easily understood manner
Organize & represent data/research findings in a simple fashion – objectives #8 & #9
These two performance objectives intersect with the others in a seamless fashion, as industry documentation are used and evaluated against criteria that have been established in the research. In addition, the preparation for the course final project is also an opportunity for students to practice these skills. To prepare, the instructors meet with the student in a series of sessions to

ensure students are on the right track for their final project and can organize and represent their findings clearly.

From these 9 performance objectives, a total of 17 class activities were derived (Table 2). Activities utilized documentation and samples from industry projects to ensure applicability and perceived utility were maximized so as to encourage learning.

Table 2 – Class Activities

#	Activity	Details
1	Draw out sequence of sourcing	Draw out the sequence of the entire sourcing process, from an owner need being identified until the project/service is re-competed. Include both vendor & owner tasks.
2	Scenario-based scope group activity	Students will be given project constraints in the format of an abbreviated RFP to build a LEGO car. The RFP & proposal process takes place in the span of a single class period in which students: form their company (they pick group members with 2-3 students/group), review the RFP & scope, ask the owner any questions (instructor), the owner formally responds to all questions/issues an addendum, students utilize the materials they were given to meet the specifications for the scope listed in the RFP, student companies submit their LEGO car for proposal review, & the owner evaluates the proposal responses & car based on the criteria listed in the RFP.
3	RFP Search	Search for an RFP online & bring a copy of that RFP to the next class & be prepared to discuss. The RFP must contain the following in order to receive credit: both price & non-price criteria are required & there is a statement of the scope of work/what the project is about.
4	Scope Assessment of Sample Project	Read the provided scope of work. Evaluate the overall completeness & clarity of the scope. Make suggestions for how to improve/strengthen the scope.
5	Scavenger hunt for main RFP elements	Using the provided RFP list of critical elements, review the RFP you found previously to see what key elements are missing & make suggestions for improvement.
6	Vendor outline of potential proposal	Read the provided RFP. Create an outline for how you would respond to this RFP as if you were a vendor assembling your proposal. DO NOT create a full proposal/response! Instead, create a template/outline of what your response would look like. DO NOT create any marketing information, keep your outline simple & concise. List any owner suggestions for improvement of the RFP to clarify what vendors need to do in order to respond.
7	Read & review streamlined RFP	Using the provided RFP list of critical elements, review the provided streamlined RFP to see what key elements are missing & suggestions for improvement.
8	Read & evaluate Risk Assessment & Value Assessment Plans	Read & complete the provided Risk Assessments & Value Assessments & complete the provided Source Selection Plan with your ratings.
9	Create your own Risk Assessment & Value Assessment Plans	Based on the sample project provided, create your own Risk Assessments & Value Assessments as if you were the vendor.
10	Watch & evaluate interviews	Watch & evaluate the recorded vendor interviews & complete the provided Source Selection Plan with your ratings.
11	Interpreting evaluation matrix results	Given the following evaluation results & analyses for each project, circle which vendor you would proceed with & why.
12	Interpreting evaluation matrix results & creating a debrief	Pick which vendor to prioritize from the following matrix & create a 1-pager about why to move forward with a particular vendor. Pick one unsuccessful vendor and create a debrief that justifies your selection.

13	Review a vendor's full proposal & to red flag assessment	Read the provided vendor proposal & evaluation matrix (vendor A was selected). Identify any issues or "red flags" you see as being potential deal breakers to this project that may cause surprises to the owner in the future.
14	Review a vendor's pre-project planning document	Read the provided vendor pre-project planning document & make suggestions for improvement.
15	Create & make suggestions for metrics for a project	Identify the top 2-5 executive-level metrics for the project/service below. Include a brief description for each proposed metric. (have a table for them to fill out - no., unit, description, etc.)
16	Review a weekly & make improvement suggestions	Read the provided Weekly Risk Report & make any suggestions for improvements on how the vendor can better improve communication and resolution of issues.
17	Final paper/presentation	Given the provided list of project ideas, select the idea that is most appealing/interesting to you. Create a 3-4 page paper on your topic of choice that relates the topic to the class & summarizes the impact of your topic on your potential future career. A minimum of 5 references must be used, references can be from publications, reports, surveys/interviews, &/or academic journals.

Example: Scenario-based scope (Activity #2)

Each activity was designed to help the students understand the various aspects of the procurement process, founded on real-examples as much as possible. Activity #2, in particular, helped illustrate the importance of clear a clear project description in a highly engaging manner. The activity required students build a LEGO car based on the scope provided. Three different types of scope were developed to illustrate the different quality and clarity of actual scopes that owners typically provide. The students were evaluated according to the "cost" to build their car (each LEGO piece represented $1) and the evaluators' subjective rating of the car. Each student team was given the same amount and types of LEGO pieces. The three different scopes were:

1. **Type A: Minimal Scope.** The only scope provided was literally, "build a car." This represented projects where the owner does not provide sufficient information on what they want or what their budget is.
2. **Type B: Detailed Scope.** The scope provided three detailed pages describe every minute detail of the car. It also included expectations that were not even realistic (i.e., daytime running lights). Many times in construction or services contract, the level of detailed provided can range in the hundreds of pages, and may not be achievable.
3. **Type C: Ideal Scope**. This scope provided a simple, but clear description of what type of LEGO car the owner wanted, a total budget, and even a graphic "rendering" of the finished car. This scope type represented the ideal approach to describing project requirements.

Being the first use of this activity, the researchers focused mostly on the logistics of executing the Activity. However, some anecdotal data was collected. Students given the Minimal Scopes generally designed the most exquisite cars, as no budget and very minimal directions were provided. Students with the Detailed Scope had trouble finishing their LEGO cars on-time, and produced cars that were extremely simple in nature. Finally, students with the Ideal Scopes developed cars that best matched the expectations while also minimizing their total "cost". A future paper will present the results of multiple iterations of this Activity, and documenting the impact of each scope type on the student outcomes. Figure 1 shows one of the student teams building their car.

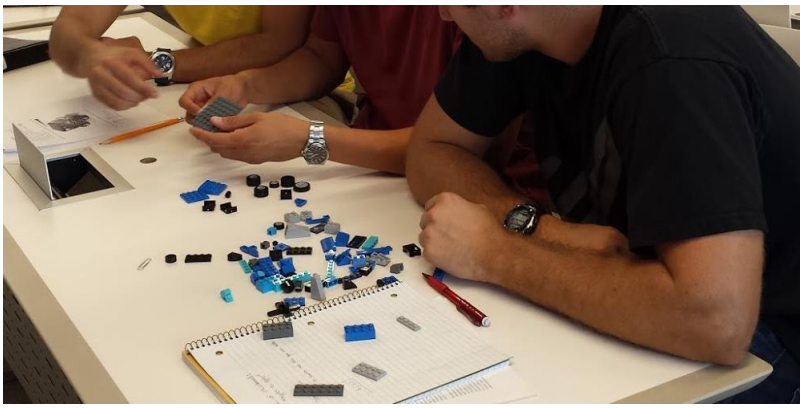

Figure 1. A team building their LEGO car (Minimal Scope).

Data Analysis & Results

Students' Demographics

Due to the course being an elective, there were a variety of student backgrounds and previous experiences that positively impacted the dialogue and diversity of student insights (Table 3). For example, both semesters had several business and supply chain students. Their alternate perspectives, especially during collaborative group work, were beneficial to the students and broadened their viewpoint as to the application of the course concepts.

Table 3 – Students' Demographics

No.	Criteria	Spring 2015	Fall 2015
1	Student enrollment	12	17
2	Graduate students	5	8
3	Undergraduate students	7	9
4	Number of Construction Management students	9	12
5	Number of Construction Engineering students	0	3
6	Number of Business/supply chain students	3	2
7	Average # of years of industry experience	5	10

Course Metrics

The course was assessed across both semester using the metrics of student enrollment, final project average rating, and course ratings (Table 4). The largest increase was seen in student enrollment (increased by 42 percent), which illustrates an increase in student desire to attend this elective course and potential perceived need of the skills taught in the course. As new elective courses are common to this university, the researchers received feedback that a majority of the students chose this course because a student from the previous semester recommended it. An increase in the quality of students' final projects was also observed and suggests that students' performance overall in the fall was superior to the spring.

Table 4 – Course Metrics Results

No.	Criteria	Unit	Spring 2015	Fall 2015	Change
1	Student enrollment	#	12	17	42% increase
2	Final project average rating	1-10, with a "10" being the highest rating	7.0	9.0	20% increase
3	Course ratings	1-5, with a "5" being the highest rating	4.9	4.7	4% decrease
4	Course rating response rate	%	86%	94%	9% increase

Self-Efficacy

The researchers also used self-efficacy in an effort to further assess the effectiveness of the course beyond the traditional forms of assessment and to determine if the needs identified were being met. Self-efficacy is defined as, "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances"[6]. This particular measure was investigated because of the potential link between learning/transfer of skills to the workplace and self-efficacy. Expectancy has been seen to influence behavioral instigation, direction, effort, and persistence[6]. The researchers used Schunk's (1991) model for self-efficacy. The results of the students' self-efficacy ratings show that in all areas of desired performance, students' self-efficacy scores improved from pre-course to post-course (see Table 5). As the researchers only discovered measures of self-efficacy recently, the results shown are only for the fall 2015 semester. Future semesters will utilize the self-efficacy assessments and be compared to previous semesters' results. Furthermore, the researchers will be collecting self-efficacy ratings in other, unrelated construction classes in an effort to serve as a baseline measurement of the new courses' overall level of effectiveness.

Table 5 – Student's Self Efficacy Results

No.	Area of Desired Performance	Pre-Course	Post-Course	Difference
1	Identify the steps of the sourcing process	2.1	4.9	127% increase
2	Identify the elements and characteristics of effective RFPs	2.4	5.4	121% increase
3	Evaluate the quality of a scope of work	2.6	5.1	92% increase
4	Generate executive-level vendor performance metrics	2.2	4.7	113% increase
5	Identify practices to increase fairness, transparency, and accountability in organizations	2.6	5.1	92% increase

*Scale of 1-6, with a "6" representing very confident that I can perform this task independently, and a "1" representing not confident that I can perform this task independently.

Conclusion

A new course in sourcing, contractor selection, and management was designed and tested across two semesters in a large university's construction management department to work towards meeting the need for more business and professional courses to better prepare students for employment in various management positions and working with various stakeholders. Based on testing across two semesters, the course has experienced positive results. The largest increase

was seen in student enrollment (increased by 42 percent), which illustrates an increase in student desire to attend this elective course and potential perceived need of the skills taught in the course. Both undergraduate and graduate students enrolled in the course, with some business students enrolling as well. An increase in the quality of students' final projects was also observed and suggests that students' performance overall in the fall was superior to the spring. A decrease was experienced in course ratings (decreased by 4 percent), which is disappointing, but can vary from semester to semester by a small amount due to specific student experiences. The response rate did increase by about one student.

An exploratory measure, self-efficacy, was tested in the most recent semester and results showed increases in student self-efficacy across all performance objectives. While self-efficacy is a common construct in psychology, future testing is needed to determine the impacts of self-efficacy on construction management students' performance and professional employment.

This course can be used as a model for instructors to consider in their development of similar business and interdisciplinary courses. Backwards instructional design can also be used in a similar fashion to design future courses based upon a particular outcome, likely driven by the industry or professional needs of future graduates. Future testing of this course will involve isolating students' reasons for taking the course, separate out students' course ratings by category to determine reasons for decreases in ratings, continued testing of the self-efficacy rating, validation of the self-efficacy measures, and potential follow up surveys to students upon graduation to further measure learning transfer. Future research should also look to apply students' self-efficacy scores to other construction management courses.

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