

Assessment of an experimental five-day graduate student construction science "boot camp" at a research-intensive university: A case study

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The applied nature of the construction science/management discipline, and the career objectives of graduate students who attend such programs, do not always comfortably align with the stated mission of research-intensive universities. As many entering graduate students do not already hold undergraduate degrees in construction science, the challenge is to free up sufficient curricular time to engage students in advanced research while still filling in their knowledge gaps. As a case study, this paper documents the outcomes of an experimental five-day pre-requisite graduate program of construction science "boot camp" within a research-intensive university. Preliminary findings suggest the structured program helps orient students to construction processes in the US and reveals to them what they don't know—but need to learn. However, some suggest the program may be better delivered in a shortened version. One unexpected observation is that the program appears to have built camaraderie among those who take the program together. This outcome—especially for those who leave their home countries for the first time and have been known to experience extreme loneliness—appears to offer a substantial benefit.

Key Words: graduate students, construction management curriculum, boot camp, pre- and post-tests

Introduction

In the Carnegie Classification of Institutions of Higher Education model, doctoral universities with the highest research activity are classified as R1. Construction science, also known as construction management, does not fit easily into an R1 university model. Chinowsky and Diekmann (2004) wrote that construction management has struggled for decades to find a suitable disciplinary home, and its attempt to fit in the engineering discipline has been less than successful at many universities. This is in part because research-intensive universities reward tenure-track faculty with original, published research. Academic research faculty rely heavily on graduate students to assist with data collection and writing, yet students with foundational training in construction management tend not to pursue graduate-level construction management degrees. Orczyk et al. (2007) argued that low enrollment in graduate programs in this field may be due to three factors: (1) there has been 100% placement of students from undergraduate construction management programs since 1990; (2) employees are not willing to give up full time positions to become full-time students, and (3) historically, construction companies do not financially reward employees for advanced degrees. Even in countries outside the US, such as Spain, there is a perception among construction management students of intrinsic barriers to employability for graduate students of construction management, such as displaying a preference for only well-paid and comfortable jobs (Torres-Machi et al. 2013). These realities and perceptions are compounded by expectations from students and potential employers that students be made "job ready" by the time of graduation (Benhart and Shaurette 2014). Program administrators must face a real conundrum where students who elect to pursue a degree in construction management do so primarily to change careers; research faculty are in turn forced to devote precious research time to teaching foundational courses to incoming graduate students. This may partly explain why only 20% of American universities which offer accredited civil engineering degrees also offer Masters programs in construction engineering management (Aditi 1984; Aditi and Polat 2010). Additionally, according to a survey of 16 construction management programs by Lee et al. (2013), the number of graduate students is typically very low (11% of the number of undergraduate students), and external research funding ranges from zero to just $250,000. The slow march of research innovation in the field may also partly explain why, at least from 1982 until 2008, there was very little difference between course content over time

and between programs, as revealed in a study of 41 masters level construction engineering and management programs over the course of over 25 years (Aditi and Polat 2010).

Considered by some to be a vocational stepchild, those from more traditional research fields, sometimes perceive construction management as an applied science and therefore do not recognize its potential as a field for full doctoral research. Evidence of this confused perception is the variable location of the subject under different disciplinary umbrellas, e.g. within business schools, such as at the University of Denver, within engineering schools, such as at University of California at Berkeley, or within architecture schools such as at Texas A&M University. Augmenting this complexity is the expectation by an R1 university of tenure track faculty to engage in original research and publish results. Since tenure-track faculty also teach, their research productivity is typically linked to the ability of a program to attract and retain graduate research students who assist with their research. Although this is also an expectation for those affiliated with many departments (e.g. chemistry, biology, physics, etc.), the field of construction science is complicated by the reality that most students who are attracted to a graduate program typically come not to embrace a career as a research academic, but rather to pass through an entry portal into the construction industry. In other words, it has been observed that many post-graduate students perceive a graduate program as a change-of-career opportunity rather than as a chance to engage in academic research. This disconnect between the need for tenure-track faculty to produce original research and publish as part of Texas A&M's Department of Construction Science (COSC) and the true motivation of entering graduate students sets the context for this paper and subsequent investigation.

Texas A&M (TAMU) opened its department of Construction Science (COSC) in 1946. In the mid-1970's, TAMU's COSC department started admitting graduate students to parallel its undergraduate degree program. Those who applied for entry to the MSCM program typically (though not always) hold undergraduate degrees in fields related to construction management, such as civil engineering or architecture. Currently over 1000 undergraduates, 35 masters-level students, and 16 doctoral-level students (architecture with a construction science area concentration) are enrolled in the program. Until 2015, the department required entrants to demonstrate competencies in five basic areas by asking students to sit for comprehensive, subject-area levelling exams, with the expectation that those who could not pass specific exams would be required to fill gaps in their knowledge by taking relevant courses (Figure 1) before being permitted to engage in research or take elected courses. For a two-year masters degree program, this requirement meant students generally did not embark on research until late into the second semester or beginning of third semester, rendering unrealistic high-quality, in-depth research with their faculty advisors. For a department without a formal PhD program but with a stated requirement for tenure-track faculty to publish and win federal grants with the help of its transient graduate student population, the existing system became untenable. In response, the department eliminated all leveling exams and made core courses optional and at the discretion of the student and his or her advisor, so that masters students could begin research immediately during the first semester of their graduate degree studies, thus facilitating higher quality, in-depth research partnerships with their advisors. This strategy liberated student and faculty time to engage in additional research and publication. While this restructuring at first appeared to offer a reasonable solution, several faculty started noticing the emergence of alarmingly naïve questions in their advanced graduate-level classes. For example, in a graduate course on advanced productivity, a graduate student recommended that the department teach a "new" type of scheduling process called "critical path method." Startled to receive such a question in an upper-level course, the instructor asked by show of hands how many of the students were familiar with terms such as "Gantt chart," "bar chart," or "float." The silence of the students led to a very real concern that permitting students to voluntarily opt out of core courses could ultimately jeopardize the quality and reputation TAMU's graduate degree in construction science. It was acknowledged that the need to engage graduate students in research cannot be at the expense of the students who, as was eventually revealed, appeared unaware of their own gaps in foundational construction knowledge.

In the fall of 2017, the department took corrective action by implementing an experimental five-day pre-requisite program (a.k.a. "boot camp") which was made mandatory for all incoming graduate students, regardless of prior background or experience. The intensive boot camp began one-and-a-half weeks prior to the first day of classes. The logic was that, although some students might not need to—nor elect to—take a full semester of a subject, they would at least "know what they didn't know" and appropriately seek assistance as necessary once they entered the construction industry following graduation. The intent was to give students an intensive educational overview of the industry and its body of knowledge before classes formally began, while simultaneously freeing up time to engage in graduate-level research at an earlier point in the program than was done prior to 2016.

Because the boot camp is still experimental and has thus far been offered only twice—in the fall of 2017 and 2018—anonymous student evaluations were conducted on the fifth (last) day of the boot camp, as well as nearly nine months after the first offering. The research team secured TAMU Institutional Review Board approval for collection and analysis of the survey results.

COSC 601 Construction Practices: Materials and methods of construction with emphasis on the design and construction process; includes structural steel and other metals, foundation materials, precast and tilt wall concrete, concrete reinforcement including pre-stressing, wood dimension lumber framing, and heavy timber framing. *Credits 3.*
COSC 602 Construction Cost Estimating: Determination of quantities for various types of construction materials and works including earthwork, foundations, structural systems, mechanical and electrical systems, and building finishes; methods used for pricing of construction works including labor, materials, equipment, sub-contractors, overhead and profit; use of various types of cost data catalogs available in the industry. *Credits 3.*
COSC 603 Construction Scheduling: Introduction to commonly used techniques and computer applications for the planning, scheduling, monitoring, and controlling of construction projects; includes key scheduling techniques such as Gantt Chart, CPM, PERT, LSM, and EVM; practical scheduling practices such as tracking, controlling, and forecasting trends of schedules, cost control, and reporting. Prerequisite: COSC 602 or equivalent. *Credits 3.*
COSC 606 Mechanical and Electrical Construction: Building environmental systems with a major emphasis on the design and control of the heating, ventilation and cooling systems, plumbing and drainage systems, electrical, fire and lightening protection, and lighting; design opportunities, calculations, equipment selection and economics as they relate to design and construction. *Credits 3.*
COSC 608 Structural Principles and Practices: Investigations into practical applications of structural design including the analysis and design of structural members in steel and concrete; surveys and studies of various structural systems. *Credits 3.*

Figure 1. Until 2015, TAMU students embarking on a graduate degree program in construction science were required to take leveling exams in five (5) subjects; those who failed the exams were required to take a full semester course covering the subject in which they failed.

Methods

In the spring of 2017, graduate students who had been admitted into TAMU's program were notified in their admission letters that participation in a five-day construction management pre-requisite program for graduate students would be required, and that they would therefore need to arrive on campus at least two weeks prior to the start of classes. The fall 2017 boot camp was offered on August 17, 18, 21, 22, and 23 and the fall 2018 boot camp on August 16, 17, 20, 21, 22. The dates fell on a Thursday, Friday, Monday, Tuesday, and Wednesday—but not Saturday or Sunday—so that students had a weekend in between to refresh. Instruction was divided into full day (8 hour) modules, where each module covered a different subject area and was taught by a unique instructor who specialized in that topic during the regular school year. The boot camp ran from 8:00 am-5:00 pm and included a lunch break complete with free food (e.g. sandwiches, pizza, etc.) provided by the department, where students had the opportunity to interact informally with one another, as well as with boot camp faculty. The fifth (final) module of the boot camp was a summation of what the students had learned that week. Shorter in duration, time remained for the students to take a written survey about their boot camp experience, as well as to be given an overview by the department's graduate coordinator, who outlined graduation expectations, course offerings, as well as resources available to graduate and international students while at TAMU. Modules of the boot camp were as follows:

- *Module 1*: Overview of the construction industry and project delivery
- *Module 2*: Materials and methods
- *Module 3*: Estimating
- *Module 4*: Scheduling
- *Module 5*: Capstone

At the start of each module, faculty administered a 20-30 minute *pre-test* of that module's material. They also asked students to take a *post-test* consisting of identical questions at the end of the day's module. The intent of the matched pre-/post-test strategy was two-fold: (1) so the faculty could gain an understanding of the knowledge base of graduate students at the time of entry, and (2) to motivate students to stay engaged throughout each full-day of instruction.

Student Surveys

In a paper-based survey given immediately following module 5 both in the fall of 2017 and 2018, students were asked to respond to the following questions about *each module*, where questions "a" through "d" were repeated for each module (i.e. Q1a, b, c, d; Q2 a, b, c, d, etc.)

Questions 1-5

a) What are two (2) things you felt were *most* valuable to you during this module?
b) What are two (2) things you felt could be *improved* during this module?
c) On a scale of 1 to 7, where 1 is "not valuable at all" and 7 is "extremely valuable," please circle how you felt this module was *overall*:

Not effective at all ←1 2 3 4 5 6 7 → Extremely effective

d) Please indicate below what you feel is the effectiveness of this module in preparing you for the MSCM program.

- □ Not effective
- □ Somewhat effective
- □ Effective
- □ Very effective

On the last page of the 6-page total survey, respondents were asked to respond to three overall questions:

Questions 6: Please rank the module in order of value where 1 represents the most valuable and 5 represents the least valuable to you. Feel free to give the same rank to two or more modules, if appropriate. (Note: This question included a table with each module number, date of delivery, and instructor's name)

Question 7: What advice do you have for future participants in the workshop?

Question 8: What logistical help was needed in order for you to attend this five-day construction management pre-requisite program?

- □ Meals
- □ Transportation
- □ Housing
- □ Other (please explain below)

Spring 2018 Survey

Nearly nine (9) months following the fall 2018 boot camp, a second post-boot camp survey was administered to students to gather students' perception of the boot camp's effectiveness following nearly two full semesters of coursework. During the spring of 2018 the second post-survey was administered on-line to students who attended the fall 2018 boot camp. Response rate for the second post-survey was 67 percent (12 of 18 students). While the second post-survey explored satisfaction with various courses, two questions specific to the boot camp experience will be addressed here. They were:

1) The purpose of the boot camp was to provide new graduate students with "leveling" knowledge to provide a foundation for their program. How well do you feel this goal was accomplished?

- □ Not at all
- □ Somewhat
- □ Completely

2) Do you feel that participation in a pre-graduate program boot camp should be required for all entering graduate students?
   - □ Yes
   - □ Maybe
   - □ No

Results and Analysis

Average pre/post-examination scores per module were collected and are summarized in Figure 2. Percent performance improvement of post-test scores over pre-test scores were as follows: Module 1 (*Overview:* 71%); Module 2 (*Materials and methods:* 147%); Module 3. (*Estimating:* 104%); Module 4 (*Scheduling:* 112%); and Module 5 (Capstone: 477%). While post-test examinations score improvement appears greatest for Module 5, the instructor for that module explained he permitted students to complete missing answers to their "tests" during instruction, enabling all students to achieve a 100% score. This was not the case for the other modules, where the instructors gave students closed-book tests at the end—as well as the beginning—of their respective modules.

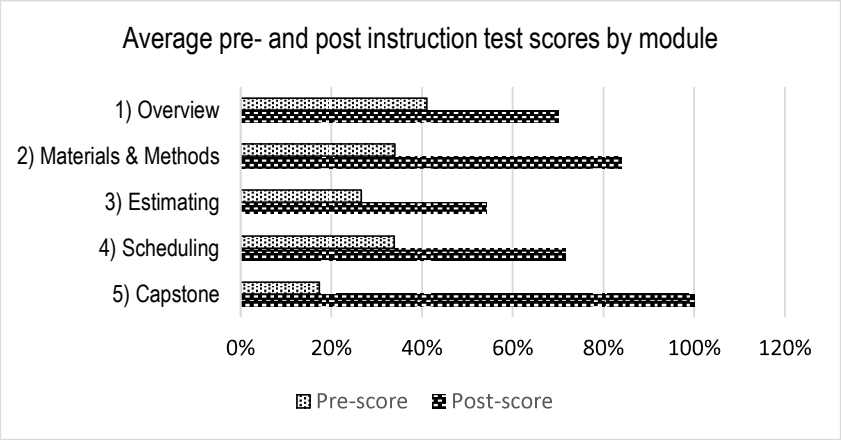

Figure 2. Average pre/post-instruction test scores by module

Samples of handwritten feedback to Question 1-5a (that which was most valuable) included: good introduction to the department and the MSCM program; helpful overview of US construction methods and terminology for international students; great faculty-student interactions; humor from faculty presentations and opportunities to meet professors informally were appreciated; live bid-day simulation for the estimating module was very effective; inclusion of real world examples to accompany theory were helpful when given. Samples of handwritten feedback to Question 1-5b (that which could be improved) included: reduce length of time per day as it was difficult to retain focus; reduce amount of information taught in one day; avoid focusing on a single PowerPoint slide for too long; and avoid time conflicts with university orientation activities that forced some students to choose and miss one or more boot camp modules. A number of students expressed appreciation for the informal daily lunches which were provided to them free of charge, but they also requested a greater variety of meals. For Questions 1-5c, tabulation of participant survey results for Modules 1-5 from fall 2017 and 2018 (Table 1) suggests the average satisfaction level among participants was high (i.e. mean of 6.0 and 6.1 out of 7, respectively). There was also a relatively high level of agreement among participant ratings (i.e. standard deviation of 1.0 and 0.8, respectively), perhaps because all boot camp faculty had significant prior experience teaching their subject matter.

Reponses to Question 6 where participants were asked to rank modules in terms of effectiveness have been summarized in Table 2. Note that while the "mode" rank among faculty members varied, the actual means for ranks were similar for all faculty, suggesting students showed only minor preferences for instruction by specific faculty.

Spring 2018 Survey

Results from the spring semester post-survey were collected and assessed. In response to the question: How well do you feel the goal of providing new graduate students with leveling knowledge was accomplished, nine (9) out of twelve (12) (i.e. 75%) responded either "somewhat" or "completely" (Figure 3).

Also, in response to the question about whether participation in a pre-graduate program boot camp should be required for all entering graduate students, nine (9) out of eleven (11) (i.e. 82%) responded either "maybe" or "yes" (*note*: one respondent did not respond to this question). Feedback from students who felt the boot camp should be required included a comment that there were "students from all different backgrounds i.e. civil engineering, architecture, computer science. These sessions demonstrate the fundamentals of the commercial construction industry."

It was predominantly these responses to the spring 2018 survey that prompted the graduate program team to again offer the boot camp to the fall 2018 entering graduate student class.

Table 1. Tabulation of scores from participant surveys per module where 1 represents "not all effective" and 7 represents "extremely effective."

	Frequency of Response									
	2017					2018				
Selected	Module No.					Module No.				
Response	1	2	3	4	5	1	2	3	4	5
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	1	0	1	0	0	0	0	0	0	0
4	0	3	1	0	0	0	2	0	0	0
5	3	3	2	4	7	5	1	2	4	0
6	9	6	6	8	2	4	4	6	6	5
7	5	5	8	5	8	4	3	4	2	6
Mean	**5.9**	**5.8**	**6.1**	**6.1**	**6.1**	**5.9**	**5.8**	**6.2**	**5.8**	**6.5**
Std Dev	1.0	1.1	1.2	0.7	1.0	0.9	1.1	0.7	0.7	0.5
Median	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	7.0
Mode	6	6	7	6	7	5	6	6	6	7
N (Nos.)	18	17	18	17	17	13	10	12	12	11
Avg all			**6.0**					**6.1**		
Avg St Dev			1.0					0.8		

Discussion and Conclusions

At Texas A&M University, both the undergraduate and graduate level programs are accredited by the American Council for Construction Education (ACCE). For bachelor degree programs the ACCE specifies that a minimum of 120 semester hours (180 quarter hours) is required for accreditation (ACCE 2017a). However the master's degree program is 32 semester hours. For a master's degree program accreditation by ACCE, the following program learning outcomes must be met: 1) critical thinking and creativity; 2) problem solving and decision-making; 3) effective and professional oral and written communications; 4) use of information and communication technology; 5) principles of leadership in business and management; 6) current issues in construction; 7) complex project decision making and associated risk management; 8) professional ethics including application to situations and choices; 9) advanced construction management practices; and 10) research methods (ACCE 2017b).

While these learning outcomes are not prescriptive, at TAMU, there is a recognition that students who graduate with an advanced degree in construction science should at a minimum leave with a foundational understanding in the following topics: construction practices, construction estimating, construction scheduling, electrical and mechanical construction, structural principles and practice.

The ACCE *Document 103MD: Standards and criteria for accreditation of master's degree construction education programs* stipulates: "Assessment shall be by peer educators from other programs in concert with construction practitioners, representatives of the construction industry associations and organizations, and society at large" (ACCE 2017b p.1). While for a 32-hour program, there are additional electives available, at TAMU the above listed

coursework is viewed as essential to functioning as a construction manager (i.e. "society at large" as represented by potential employers in the construction industry), and therefore taking the above core courses should be considered non-negotiable. It was to respond to this demand—while simultaneously freeing up time for faculty to engage graduate students in academic research—that the Five-day Construction Management Pre-requisite Program for Graduate Students ("boot camp") was developed and offered.

The boot camp for incoming students has enjoyed some success in terms of preparing students for the MSCM program. Anecdotally, several staff and faculty observed that the boot camp appears to have increased student awareness of the gaps in their own knowledge. Students seemed more motivated and voluntarily opted into taking rigorous core courses without faculty prodding. Several faculty of full-length semester-long courses report that students seem more knowledgeable and self-confident since the boot camp was instated. For example, one faculty member who taught graduate-level scheduling following the 2018 boot camp observed: "One critical issue is a lack of construction engineering management knowledge of incoming students, especially career change students. Our program is being used as a job training opportunity for career change students. I can see a clear benefit from the boot camp. The boot camp students in scheduling are clearly doing much better than the students who didn't take the boot camp."

Ironically, one of the benefits of the boot camp was unexpected because it had less to do with academic preparation (cognitive domain) and more to do with enhanced bonding (the affective domain) between graduate students within an entering class. A number of faculty and staff independently observed a greater comfort level, laughter, and bonding between graduate student classmates following the boot camp experience than in pre-boot camp years. On another point, recommendations to reduce the amount of information and number of hours per day are being taken seriously by boot camp faculty and staff, and there are plans to shorten the number of days to avoid conflict with other entering graduate student activities required by the university—although not all faculty agree the boot camp rigor should be lessened, given the nature of the construction industry students will enter upon graduation. But the unanticipated benefit of increased camaraderie—especially valuable for international students who often experience loneliness while away from their home countries for the first time—has led to suggestions to introduce group outings and network-building ice-breaker activities as well. As before, a second follow-up post-survey will be administered nine (9) months after the fall boot camp to help guide the department's final decision in this respect. Ultimately, a longitudinal survey of graduates five or more years after commencement who took the boot camp versus those who did not, will offer the best guide as the long-term effectiveness of the program.

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Table 2. Tabulation of participants ranking of value of modules, where 1 signified the "most valuable module" and 5 the "least valuable module."

2017						2018					
	Module						Module				
Respondent	1	2	3	4	5	Respondent	1	2	3	4	5
1	5	4	3	2	1	1	1	4	3	2	*
2	4	2	3	5	1	2	3	2	2	3	1
3	5	4	1	2	3	3	3	1	4	2	5
4	5	3	4	2	1	4	2	*	4	1	3
5	5	3	2	1	4	5	3	*	2	4	1
6	1	3	2	2	2	6	1	1	1	1	1
7	5	3	4	2	1	7	5	1	2	4	3
8	5	4	5	5	4	8	2	1	4	3	5
9	2	5	1	3	4	9	4	2	3	5	1
10	1	3	2	2	2	10	1	5	2	4	3
11	2	3	3	1	4	11	1	2	1	3	2
12	2	2	1	3	1	12	1	2	*	*	*
13	4	3	5	2	1	13	3	5	4	4	5
14	3	1	2	2	1						
15	1	3	1	2	3						
16	2	1	1	2	2						
17	2	5	3	1	4						
18	2	2	4	*	4						
Mean	3.1	3.0	2.6	2.3	2.4	Mean	2.3	2.4	2.7	3.0	2.7
SD	1.6	1.1	1.4	1.2	1.3	SD	1.3	1.6	1.2	1.3	1.7
Mode	5	3	1	2	1	Mode	1	2	2	4	1

* Missing results due to students who were periodically unable to attend the boot camp due to time conflicts with existing employment obligations or university-required orientations for international students.

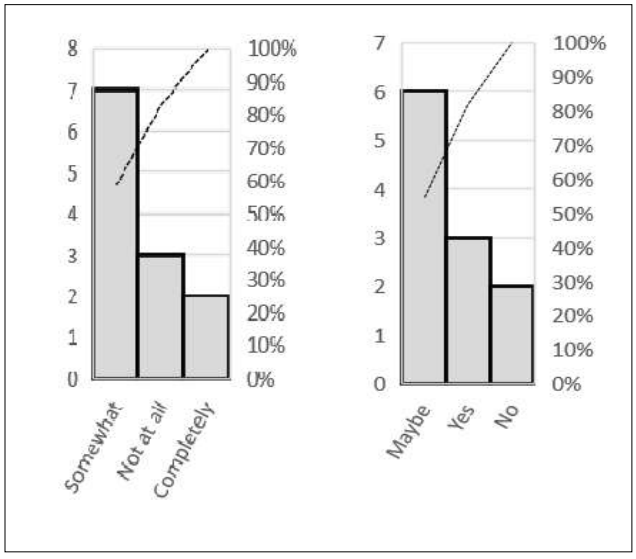

Figure 3. Both Pareto charts represent results of the spring 2018 follow-up survey. The chart on the *left* is in response to Q1 about how well the participant felt the boot camp provided new graduate students with "leveling" knowledge to provide a foundation for their program. The chart on the *right* plots responses to Q2 about whether the participant felt the boot camp should be *required* for all entering graduate students.