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Site Development Knowledge for Entry-Level Construction Professionals: Academic Perceptions

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Site development activities are crucial to construction projects, yet construction management (CM) programs typically focus instruction on building structures rather than the associated site development. Previous studies have evaluated key skills and topics being taught in CM programs yet these studies have failed to examine instruction as it relates specifically to site development. This study bridges the gap in research by evaluating the perceptions of CM academics regarding site development instruction. A survey was administered to CM faculty teaching in Associated Schools of Construction (ASC) affiliated programs in the United States. The survey included eighteen site development topics and was validated by four general contracting industry professionals and three site development industry professionals before distribution. Participants were asked to classify each of the topics within the six levels of the revised Bloom's taxonomy. The survey was completed by 35 respondents representing all seven ASC regions in the United States. When aggregating results of all the site development topics, the majority of respondents felt that students should achieve the "understand" level (Level II) of cognition by the time they graduate. The highest ranking and lowest ranking topics are also identified along with recommendations based on the findings.

Key Words: Site Development, Construction Education, Earthworks, Bloom's Taxonomy

Introduction and Background

The majority of construction project managers entering the workforce today are graduates of post-secondary construction programs. It is imperative to assess what is being taught consistently, along with what is not being taught, in construction programs across the United States (Farrow et al., 2017). Variation between programs can lead to questions concerning knowledge and skill differentials between candidates produced by the programs and the agreement of necessary skills by the industry and education sector (Farooqui & Ahmed, 2009). Colleges and universities have much discretion in what they teach, though. Accreditation entities strive to establish uniformity through common learning objectives (Leathem, 2019).

Previous studies have sought to reconcile the key skills being taught in construction management (CM) programs with what is desired by construction industry professionals (Bhattacharjee et al., 2013; Tatum, 2011; Chileshe, 2007). Farooqui & Ahmed (2009) found key differences in the level of emphasis placed on certain skills between industry and academia. For the undergraduate level, these skills included interpreting contract documents, listening ability/giving attention to details, and time management. Studies consistently identify industry's emphasis on soft skills such as communication and team building, collaborative skills, decision making, leadership, understanding of social, ethical and global issues besides other technical and design skills (Ahn et al., 2012; Bankik, 2008). Burgett et al. (2018) studied mechanical systems curriculum in CM education and found a rank of importance of specific concepts regarding this specialty area in construction projects. Extensive research has covered numerous technologies incorporated in construction education and the industry's desired knowledge levels for students (Lucas, 2016; McCuen and Miller 2017; Leathem and McGlohn 2017).

Within a specific course, varying levels of emphasis are placed on each of the course learning objectives, no matter what the topic of the course is. Bloom's Taxonomy of Educational Objectives, developed in 1965, established a series of cognitive levels of learning which helped to categorize the depth of knowledge desired for a specific topic within a course (Bloom et al. 1965). Bloom's taxonomy is commonly referenced in academia and has served as an accepted measure of academic assessment for decades. In a revised taxonomy by Anderson et al. (2001), the cognitive levels of learning were revised and include the following, listed from lowest to highest level of learning: Remember, Understand, Apply, Analyze, Evaluate, and Create. The revised taxonomy included a minor restructuring of cognitive levels and a change from noun terminology to verb terminology for outcomes. Anderson's revised taxonomy is widely used for assessment in education today. When analyzing what is being done between or across institutions for instruction and assessment, Anderson's revised taxonomy serves as a meaningful measurement tool.

Site development activities such as earthwork, logistics, and permitting are ubiquitous in the construction industry and often times critical to a project's successful completion. Yet, in CM programs, the primary focus is typically more towards the building systems themselves, as opposed to the site characteristics and site needs those structures are built on. Such has been the case in the McWhorter School of Building Science at Auburn University. The authors sought to gain perceptions of CM academics across the United States regarding their perceptions of what a CM graduate should know about site development by the time they graduate, and to what extent they should know it. No such study exists in the current literature.

Research objective and methodology

The research objective was to discern academic perceptions regarding what skill level an undergraduate CM student should achieve related to site development concepts by the time they graduate. The authors sought to determine this through surveying construction academics in the United States. The authors developed an electronic survey of both open-ended and closed-ended questions. The survey content was validated by four general contracting professionals and three site development professionals. Feedback from the validation process was incorporated into the survey instrument prior to distribution. The electronic survey was distributed via the Associated Schools of Construction (ASC) email listserv on October 14th, 21st, and 27th, 2020. The survey was finally closed on November 1st, 2020. The ASC listserv contains 940 separate email addresses.

The survey contained two sections. Section one included demographic and general questions to assess each respondent's expertise of the site development content in their respective curriculum. Those questions included collecting the respondent's current job title, university name, how many years the respondent has taught in a construction-based curricula, and specific course name(s) and number(s) of the construction management classes taught by the respondent. Another critical question to gauge the respondent's expertise was: "*What classes (if any) do you teach that incorporate any site development content as defined above? Please provide the course name and course number for each class you list*." The researchers analyzed each respondent's answers to these questions for validity of the participant's knowledge.

Section two of the survey first informed each respondent of a definition for site development and repeated the research purpose and objectives. The most substantial portion of the second section of survey provided a list of 18 separate site development topics, shown below in Table 1. The 18 topics were developed with industry input, and fit into five site development concept areas, including engineering, project management, estimating, and field operations. Survey participants were asked what cognition level they felt a student of their program should achieve prior to graduation, based on the six levels of the revised Bloom's taxonomy. Survey participants could also respond that a topic was not necessary for an entry-level construction professional to have knowledge of or about.

Table 1

Listing of site development topics included in survey

Concept area	Specific Topic
Engineering	Fundamentals of soil terminology
	Geotechnical reports
	Testing/inspection of soils
	Testing/inspection of utilities
	Soil additives (lime, cement, etc.)
Project management	Unforeseen site conditions
	Permitting
	Pertinent professionals in the field
	Communication and coordination between site development project stakeholders
Estimating	Quantification of materials
	Pricing
	Labor productivity
	Equipment selection
	Site balancing
Field operations	Safety
	Site logistics
	Erosion control
	Environmental regulations

Results

The survey instrument recorded 84 responses total. Forty-nine of those 84 responses were either: (A) significantly incomplete (less than 50% answered) and removed from the analysis, or (B) the respondent answered the classification of knowledge survey questions in a manner that warranted the

full response to be disregarded. The survey was completed by 35 validated respondents, which represents all seven ASC regions in the United States. Respondents included eight Assistant Professors, seven Associate Professors, eight Full Professors, five Lecturers/Instructors, three Professors of Practice, and four School Heads/Department Chairs. The respondents represented mainly CM programs (33 of 35) plus some individuals also taught in construction engineering, civil engineering, and architecture programs. Over 80 percent of respondents had been teaching construction-based curricula for over five years, with over 40% of respondents having greater than 20 years of experience. The respondents represented a range of program sizes, with the average number of students in their programs being 295.

Baseline definitions for each cognition levels were provided with the survey to ensure consistency amongst responses. To provide further consistency of data, specific examples were included in the survey for each of the six taxonomy levels. The examples provided were specifically related to sitework and are provided for reference in Table 2.

Table 2

Revised Bloom's taxonomy levels and examples

Level	Example
Level 0 - Not Applicable	The student does not need to know about GPS guided equipment.
Level 1 - Remembering	The student can define what GPS guided equipment is.
Level 2 - Understanding	In addition to Level 1, the student can explain what GPS guided equipment is, and how it is used for site development.
Level 3 – Applying	In addition to Level 2, the student can use GPS guided equipment.
Level 4 – Analyzing	In addition to Level 3, the student can analyze a site development project, and categorize which equipment is most appropriate.
Level 5 – Evaluating	In addition to Level 4, the student can review and criticize a plan on how to implement GPS guided equipment.
Level 6 – Creating	In addition to level 5, the student can design a plan on how to implement GPS guided equipment.

Engineering Topics

Figure 1 below provides a summary of the responses regarding the five engineering topics. As shown, Level II "Understanding" was the most prevalent response for all five of the topics. Approximately 14 percent of respondents noted that graduates should achieve "V. Evaluating" or "VI. Creating". Conversely, over 35 percent of respondents felt that knowledge regarding testing/inspection of utilities and soil additives was either not necessary for a student coming out of college, or should only be at the "I. Remember" level of cognition.

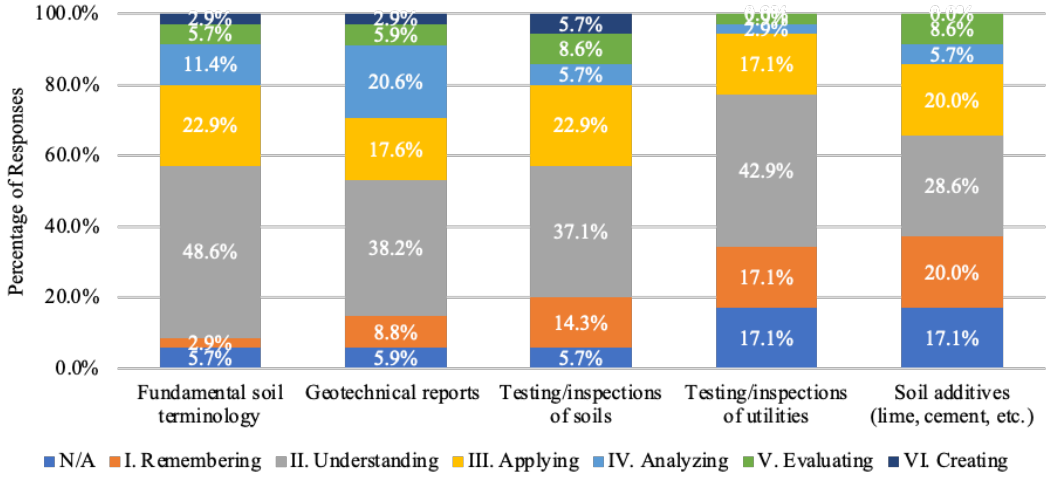

Figure 1. Engineering topics – desired level of cognition

Project Management Topics

Figure 2 below provides a summary of the responses regarding the four project management topics. The highest number of respondents felt that graduates should be at "II. Understanding" for unforeseen site conditions, pertinent professionals in the field, and communication and coordination topic areas. The highest number of respondents felt that graduates should be at "III. Applying" regarding permitting. Approximately 20 percent of respondents felt that graduates should achieve "V. Evaluating" or "VI. Creating" levels of cognition concerning unforeseen site conditions. Just over 17 percent of respondents felt graduates should achieve the "VI. Creating" level of cognition regarding communication and coordination between site development project stakeholders.

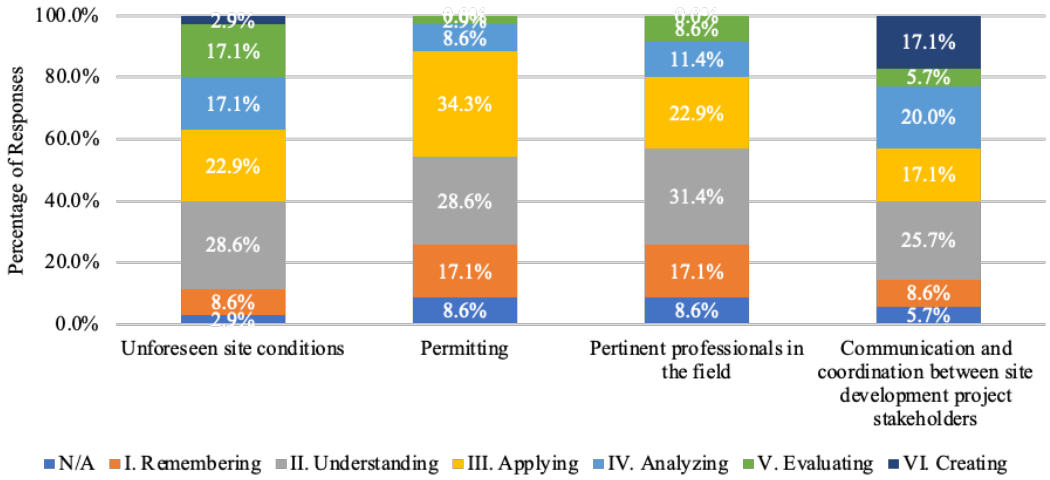

Figure 2. Project management topics – desired level of cognition

Estimating Topics

Figure 3 below provides a summary of the responses regarding the five estimating topics. Nearly one in four respondents felt that a student should achieve "II. Understanding" for labor productivity, equipment selection and usage, and site balancing by the time they graduate. Also, nearly a third of respondents felt that students should achieve a "VI. Creating" level of cognition for quantification of materials, and pricing.

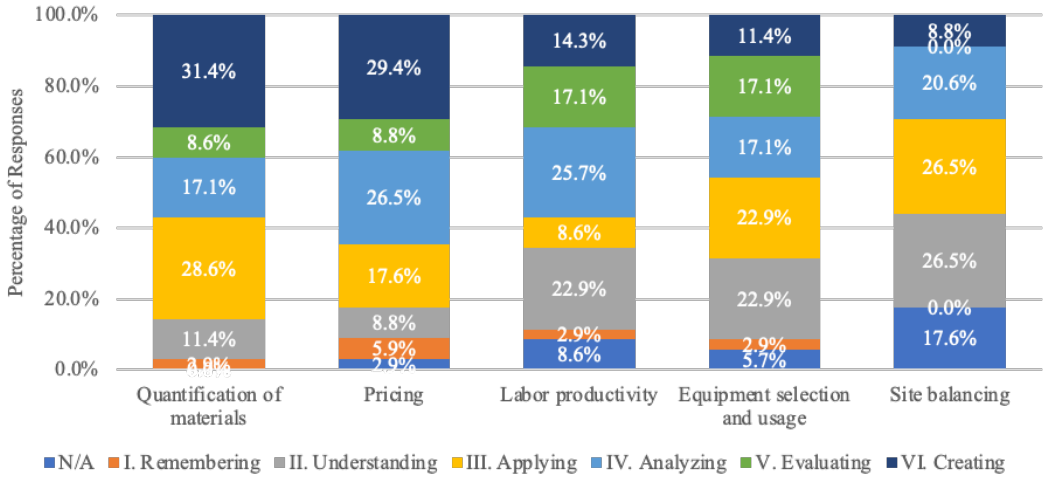

Figure 3. Estimating topics – desired level of cognition

Field Operations Topics

Figure 4 below provides a summary of the responses regarding the four field operations topics. As shown, 60 percent of respondents felt that students should achieve "V. Evaluating" or "VI. Creating" levels of cognition related to safety, while approximately 40 percent of respondents felt the same about site logistics. Respondents were split across the levels of cognition regarding erosion control and environmental regulations, with approximately one in three respondents answering that environmental regulations were either not applicable, or should be achieved at only a "I. Remembering" level of cognition by a graduate.

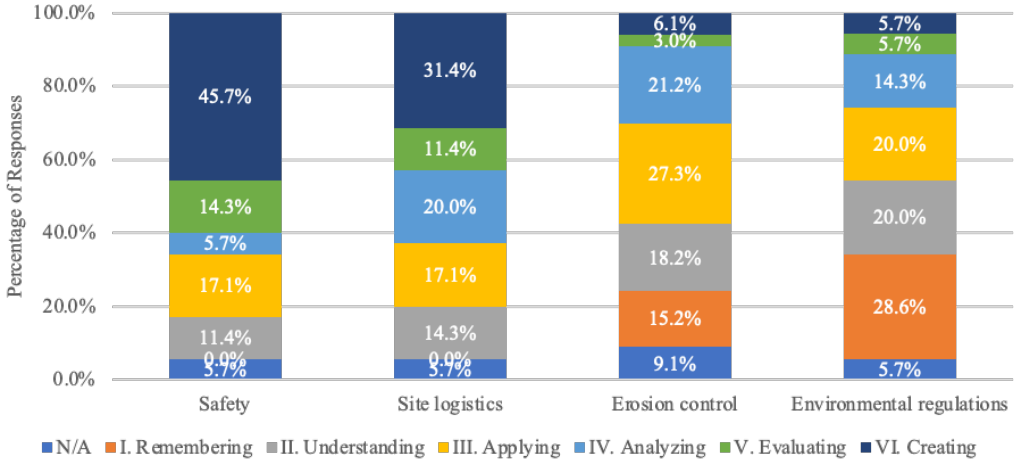

Figure 4. Field operations topics – desired level of cognition

Average Response for All Topics

Figure 6 below provides a summary of all responses. On average, 26.8 percent of respondents felt that students should achieve the "II. Understanding" level of cognition by the time they graduate. This result was followed by " III. Applying" and "IV. Analyzing." Just under 10 percent of responses fell in the not applicable category, while just over 10 percent of responses fell in the "VI. Creating" level of cognition.

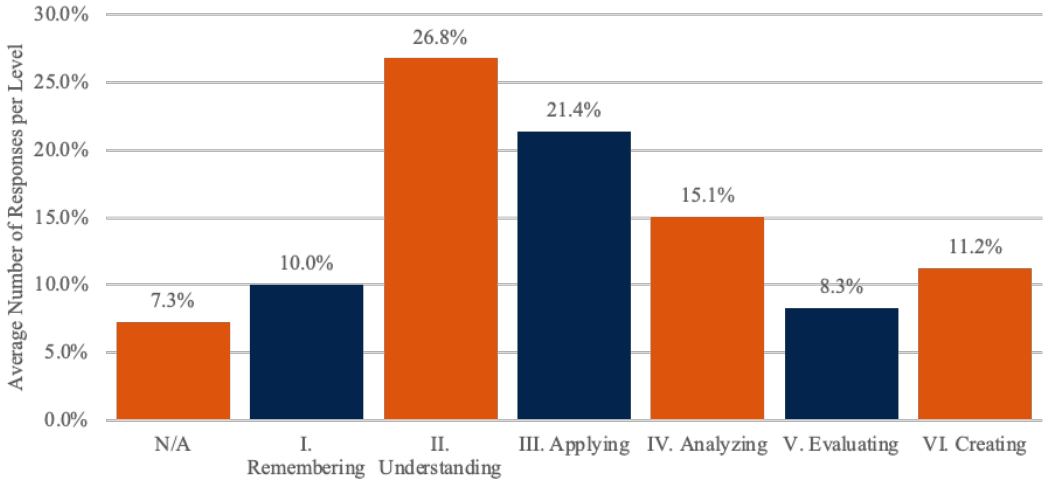

Figure 6. Average responses regarding all topics – desired level of cognition

Discussion of Results

The survey results show that, on average, academics feel graduates should gain some level of education on all of the noted site development topic areas, but only need to achieve the highest level of cognition for a few of the topics. Safety received the highest rate of "VI. Creating" responses of any of the topics listed in the survey, at 45.7 percent (Figure 4). This was followed by site logistics (Figure 4) and quantifications of materials (Figure 3) both at 31.4 percent of respondents, pricing (Figure 3) at 29.4 percent of respondents, and communication and coordination between site development stakeholders (Figure 2) at 17.1 percent. Labor productivity and equipment selection and usage (Figure 3) both had over 10 percent "VI. Creating" responses" and 17.1 percent "V. Evaluating" responses. None of the other topics had over 10 percent "VI. Creating" responses. None of the engineering or technology topics were noted highly as areas where students should have a deep knowledge by the time of graduation. These results communicate clearly the topics that academics feel students should have the deepest level of knowledge in, and be able to use when entering the field of construction full time. Hence, these are topic areas that faculty should (1) teach to a substantial degree, and (2) assess whether or not students are actually meeting this level of cognition.

There were several topics that a substantial number respondents felt were not necessary for an entry-level construction professional to have knowledge of or about, namely site balancing (Figure 3) at

17.6 percent, and testing/inspection of utilities and soil additives (Figure 1) both at 17.1 percent. These results show which areas faculty can focus the least on when teaching about site development. The authors found it interesting that such a large number of respondents felt that knowledge regarding site balancing was not required, yet to the contrary, a large number of academics felt knowledge of quantification of materials and pricing should be at the "VI. Creating" level. Project sites that do not balance, meaning they either require materials to be hauled-in to the site, or hauled-off of the site, can lead to significant costs if the off-site location material is coming from or going to is a great distance away. The authors, in their experience, could foresee all three topics being taught together in an active learning exercise where students would need to assess a site, and create a plan on how to best address the cost issues surrounding a haul-in or haul off project, while still meeting the owner's project objectives. Moreover, work related to soil additives can become very costly. Planning for how soil additives can and should be used at a substantial (i.e., VI. Creating) level may be required on a large project, or costs can quickly spiral out of control. Again, it would seem intuitive that these types of scenarios would be used to teach and assess at the higher levels of Blooms's taxonomy.

On average, respondents felt that students should achieve the "II. Understanding" level of cognition concerning all of the site development topics by the time they graduate. This result indicates that, generally speaking, CM programs should incorporate site development throughout their curriculums at an "understand" level. Specific topics should be focused on in more depth, such as those already described.

Conclusions, Limitations, and Future Research

When aggregating results of all the site development topics, the majority of respondents (26.8 percent) felt that students should achieve the "II. Understand" level of cognition by the time they graduate. Therefore, CM programs should consider incorporating the majority of site development topics throughout their curriculums at an "II. Understand" level. Topics in which a significant percentage of respondents placed at the highest level of cognition ("creating") include safety (45.7 percent), site logistics (31.4 percent), quantification of materials (31.4 percent), pricing (29.4 percent), and communication and coordination between site development stakeholders (17.1 percent). CM programs should consider incorporating these topics at a level higher than "II. Understand." Topics that respondents felt were not necessary for CM students include site balancing (17.6 percent), testing/inspection of utilities (17.1 percent) and soil additives (17.1 percent). CM programs should consider limiting or excluding these topics from the curriculum in order to focus more intently on the significant site development topics mentioned above.

Large discrepancies were noted amongst respondents for environmental regulations. These discrepancies could stem from differences in personal experience, given that environmental regulations may vary significantly by state or by region. Future research should establish a baseline level of environmental regulation knowledge desired by industry. Smaller, less obvious, discrepancies may exist among all categories due to differences in interpretation of each of the taxonomy levels, even though taxonomy definitions and examples were provided in the survey. These differences, if they exist, cannot be fully known or quantified. Future research should examine each of the site development categories included herein at a topic level for data validation. Finally, it is critical that academics continually work with their industry partners to determine what program graduates should know, and to what extent. Future research should gauge industry perspectives of site development topic cognition levels desired for recent graduates. This research is limited to CM faculty teaching in ASC affiliated programs in the United States. Future research may extend the reach of programs and locations surveyed.

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