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INDUSTRY REQUIREMENT GAP ANALYSIS FOR SUSTAINABLE CONSTRUCTION TECHNOLOGY

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INDUSTRY REQUIREMENT GAP ANALYSIS FOR SUSTAINABLE CONSTRUCTION TECHNOLOGY

by

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B.S. IN INDUSTRIAL ENGINEERING

THESIS

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ABSTRACT

As sustainable construction becomes a standard necessity in the construction industry, construction engineering and management programs seek to integrate sustainable construction concepts and skills into their degree programs. The aim of this research is to identify industry-required competencies and recognize the possible gaps between industry skills demands and the education provided by academia for sustainable construction technologist jobs. In this study, industry requirements for sustainable construction technologist (mid-level) positions were identified through the analysis of job advertisements, literature review, job analysis (i.e., Developing a Curriculum-DACUM-process), and surveys. Results from the DACUM process provided a categorization of 4 main duties and 60 tasks for the job description of sustainable construction technologist. Identified tasks were verified by conducting a survey asking about the importance level of each task and how they could be learned better (either in the job position or in a college course). Thirteen professionals working in industry participated in the survey. An in-depth review of Community College curricula was performed to compare the different programs and determine potential gaps between industry requirements and academia-offered skills. The most critical gaps identified include maintaining standard green specifications, preparing green materials lists, and researching green certifications. The identified gaps

and requirements could provide educational programs with essential knowledge about industry expectations for sustainable construction technologists while they develop and implement sustainable construction curricula. The results of this study are applicable for academia to provide students with the most recent industry-required knowledge in order for students to quickly transition to industry after graduation.

TABLE OF CONTENTS

List of Figures

List of Tables

Chapter 1

INTRODUCTION

The sustainable (green) construction market in the United States (US) has generated $167.4 billion in Gross Domestic Product (GDP) from 2011 to 2014 and supported more than 2.1 million jobs (Booz et al., 2015). According to the same report, it is expected that from 2015 to 2018, sustainable construction will generate an extra $303.4 billion in GDP and support 3.9 million jobs in the US. The size of the green building market in the US increased consistently from 3 to 81 billion dollars in nine years from 2005 to 2014 (Statistia, 2016). These statistics show the large economic impact that green building has and is expected to have on GDP in the US. This impressive economic impact shows the industry interest in this field and the increased need in the workforce for skilled graduates who can perform the jobs created by sustainable construction. To satisfy the industry demand, some universities, colleges, and institutes have started to include sustainable construction programs in their curriculums. Although there are many construction engineering, construction management, civil engineering, and architectural degree programs in the US, only a few colleges offer sustainable construction course content. For the new jobs created by sustainable construction, it is necessary for academics to have a common understanding of the dynamically changing content, principles, knowledge, and skills required by the industry to fit these types of jobs. In addition, as the benefits of green building continue to change the Architecture/Engineering/Construction (AEC) industry and as the number of green projects rises in the United States, more construction firms are gaining experience with this new way of building and changing their expectations for new hires from degree-granting construction programs. (Ahn & Pearce, 2007)

Insufficient skills for a specific occupation cause skill mismatch, which is costly for employers, workers, and society. Therefore, matching skills with jobs is a priority concern for policy makers. Although a large part of these difficulties is related to skills gaps and training deficits in specific sectors, occupations, and regions, many of them can be covered in courses offered by academia.

As a response to this concern, this research provides an approach to identify and clarify skills to be taught in 2-year programs and certificate programs in community colleges for jobs that require some advanced education and are defined as technologist positions. The first step was to explore, identify, and establish industry required competencies for workers specializing in sustainable construction technologies integrated with the cutting-edge requirements. Then, data were collected on current 2-year programs and certificate programs offered in community colleges with majors in sustainable construction. The final step was to identify the gaps between the industry-identified competencies and the offerings of 2-year programs and certificate programs.

The specific questions answered by this study are as follows:

1) What are the industry-identified competencies required for sustainable construction technologist jobs?

2) What are the gaps between industry needs and the education provided by academia for sustainable construction technologist positions?

Chapter 2

BACKGROUND AND LITERATURE REVIEW

The fast-track development of construction techniques and materials in conjunction with the slower changes in college education result in a mismatch between what industry requires from construction graduates and what academia offers. This mismatch has led many researchers to review and revise competencies and industry requirements from time to time to benefit academia by making necessary changes in curricula to meet industry requirements and create graduates who can compete in the job market.

1. Defining Job-Based Competencies

According to the US Department of Labor Employment and Training Administration (DOLETA), a competency in a position-specific competency is defined as the ability to apply knowledge, skills, behaviors, and personal characteristics to perform work tasks successfully (Ennis, 2008). Competencies are considered a necessary skill for graduates to be competitive in the job market, which makes academia's role more important in providing these necessary industry-required competencies. Educational competencies can successfully describe desired learning outcomes in industry and academia (Benhart & Shaurette, 2014). In the literature, authors use different terms to refer to the idea of competencies. These include employability skills, industry-required skills, and industry-expected skills. In this study, I use the term "competency" to describe these industry skills. Some industry-required competencies have already affected academic curricula. For instance, reading and writing are some skills existing in curricula that reduce the industry expectation gap (McGill, 2009).

Defining the competencies for a specific position consists of identifying the critical work tasks, which appear in a formal job analysis. The main aim of a job analysis is to identify specific work activities, tasks, responsibilities, knowledge, and skills needed to perform a job. Results can be used for both academia, to provide more qualified relevant curriculum to meet the industry needs, and industry, to have a united expectation from employers for a job position.

To this end, researchers used different methods of job analysis to identify industry-required competencies and skills. Job analysis methods are more common in engineering and medical disciplines than other disciplines since they exhibit faster changes in technology advancement. Radermacher et al. (2014) considered the gaps between computer science and software engineering graduates as well as industry expectations and competencies in their research through semi-structured interviews. They interviewed twenty-three managers or employment personnel asking about the areas in which recent graduates had issues at the beginning of their work and the skill deficiencies that prevented them from being hired. The results of this study provided further support of several knowledge deficiencies in current curricula including communication skills and testing ability. Kuo et al. (2014) performed interviews and surveys to identify expected competencies in the solar energy field and introduced a set of employability indicators. An interpretational model was developed by Kuo et al. (2014) to link competence, job performance, working attitude, and employability for solar training purposes, recruitment, and curriculum development.

Plessis & Van Niekerk (2014) studied three different Geographical Information (GI) Science competency sets to provide a framework of crucial competencies. They identified competencies used to provide a prototype framework of curriculum development. A group of experts rated the usefulness and importance of the basic framework of 16 knowledge areas (KAs). Then, they used the available GI Science Body of Knowledge (BoK) to develop the basic framework and deliver the new framework, which consists of 14 KAs, as a tool to develop curricula that satisfy industry needs of GI Science graduates. Mirzazadeh et al. (2014) provided a framework to meet required local clinical competencies. In this study, literature reviews and nominal group meetings with students and faculty members were initiated to raise a list of initially expected competencies. Ultimately, the final framework was proposed with eight competency domains. These identified competencies have been used to provide a baseline for curriculum development. Literature-based research on Management Information Systems (MIS) has been applied to obtain industry qualification expectations, which were eventually added to the proposed curriculum design. To validate the results, Ehie (2002) solicited feedback from fourteen industry professionals on the draft curriculum. He identified the ten most critical skills required by industry from MIS graduates to be included in the curriculum.

2. Job-based Competencies in Construction Field

Industry-expected competencies and requirements in construction management and sustainable/green building have also been studied. Ahn & Pearce (2007) conducted a survey of 87 companies that employ graduates from three main universities in the eastern US to address the rising industry expectations, experiences, and perceptions related to green building. The results indicated the growing importance of green building in the construction market and provided the baseline for the universities to understand how industry expectations change in order to provide students with the required knowledge to meet industry needs. In another study, Ahn. et al. (2012) conducted a survey of 100 construction companies located in the Eastern US to identify their expectations from graduates of construction programs. The companies were asked to rate 14 key competencies of the graduates and the result was compared with curriculum accreditation areas. The key competencies were ethical issues, problem-solving, and interpersonal abilities.

Results from an Australian study suggest that academia apply more capabilities to their curriculum to both cover industry requirements and lead the industry in innovation. In 2015, Wu et al. analyzed the new requirements arising with advancement of technology to the construction field in Australia. Wu suggested curriculum reform in construction education by considering industry needs for students' quick transition to industry after graduation. They conducted a survey of 252 construction graduates to identify significant gaps and then rate them. The results indicated that the most significant gaps were linked to problem-solving and construction technical skills. Based on an exploratory factor analysis, the identified gaps were categorized into eight groups including construction technology, information technology, problem-solving skills, construction economics, risk management, basic theories, business management, and sustainability science. The authors recommended that the existing curriculum should be reformed to meet the industry needs. Saks and Pikas (2013) provided a framework for Building Information Modeling (BIM) education that sets the fundamental topics and the levels of accomplishment required at each phase of degree programs. They utilized surveys, workshops, analysis of job advertisements, and in-depth interviews to identify the industry requirements from graduated engineers. Saks and Pikas (2013) developed a key competency for each identified topic using the cognitive domain of Bloom's taxonomy. Through a gap analysis, this study compared the latest leading universities' curricula to industry needs. The analysis resulted in a framework to develop BIM content for construction engineering and management (CEM) degree programs. Benhart and Shaurette (2014) reviewed the undergraduate construction management curriculum in Purdue University's Department of Building Construction Management in 2010 to identify industry requirements. They compared them with the current curriculum and ACCE (American Council for Construction Education) standards, which define the learning outcomes for construction graduates in 2-year and 4-year programs, and suggested changes to meet industry requirements.

Most of the methods used to identify competencies and industry requirements depend on techniques such as observations, surveys, worker diaries, questionnaires, critical incidents, interviews, and individual and focus groups in order to collect job information (Shetterly & Krishnamoorthy, 2008). The competency tasks and activities identification are considered highly reliable when the job analysis is performed by professionals from specialized industries due to their experience and knowledge in performing the job (Dixon & Stricklin, 2014).

3. Types of Jobs in Sustainable Construction

Generally, based on job descriptions and advertisements, there are three levels of sustainable construction specialists needed in industry, and each level includes a few occupations (i.e., entry-level, middle-level, and higher-level). This study focuses on the middle-level positions in sustainable construction since it is where most graduates would look for a job. Table 1 shows the typical careers in each level. Entry-level careers are mostly the ones with lower educational requirements and minimal knowledge about the job, since short on-site learning would be sufficient to do the job. Middle-level careers require some higher education and knowledge including experience in working with specific software or code enforcements. Engineering, management, and architecture positions require a high level of education, combined with several years of experience. Few jobs are available in high-level construction positions, since a company may require only one lead manager but increase responsibilities in the middle and entry level to make a project successful.

Table 1. Sustainable construction levels and careers (Mapcareer, 2013)

Level of sustainable construction careers	Careers
Entry level	• Roofer • Construction Laborer • Solar Photovoltaic Installer • Landscaping and Grounds-keeping Workers • Refuse and Recyclable Material Collector
Middle level	• CAD/CADD drafting/design technician • Construction Carpenter • Energy Auditor • Electronics Engineering Technician • HVAC Technician and Installer • Residential Energy Auditor • Building Inspector
Higher level	• Mechanical Engineer • Construction Manager • Landscape Architect

To begin the study, each of the middle-level jobs was researched through job descriptions on the internet independently from different job advertising websites including LinkedIn and Indeed. One hundred job descriptions were studied to have a better understanding of industry requirements for graduates. The review of job descriptions showed that a large number of middle-level jobs exists in the sustainable construction field. This indicated the industry need and included common competencies to perform the job properly, including communication skills, excellence in working with Office software, problem solving skills, and the ability to work in groups and individually.

4. Methods for Curriculum Development

Once industry expectations for skills are identified, colleges can use this information to incorporate it into their curricula. Curriculum development is considered an essential step for any new degree program and the Developing a Curriculum (DACUM) technique has been effectively used to develop the technical part of a curriculum since the 1960s (Halbrooks, 2003). It directly relies on the workers in the specific positions to describe their jobs (Johnson, 2010) and, by involving members of the industry in the curricular development process, provided several long-term benefits and a high level of cooperation between industry leaders and academia (Halbrooks, 2003). Linton et al (2011) used DACUM to build a job task analysis to identify a set of required knowledge, skills, tasks, steps, duties, and abilities to perform a food protection and defense professional position. They conducted a survey to validate the identified knowledge through the DACUM process to provide a training program. In 2016, Halawi et al. interviewed existing Information System (IS) industry experts to explore the skills needed to perform the job using the DACUM process. The results helped Halawi to design a curriculum for two graduate degrees in IS and Information Security and Assurance (ISA).

DACUM is a common method for occupational analysis because of its low-cost process and quick determination of the skills, since the ones who perform the job determine the skills. (Owens et al., 2013) DACUM is being used in more than 20 studies under National Science Foundation grants to identify industry requirements and competencies to assist in the design of curricula for customized training, certificates, and two-year degree programs helping to bridge the gap between academia and industry (NSF, 2017). The Ohio State University, college of education and human ecology, used DACUM to identify industry-expected competencies for Sustainable Construction Operations for Coast Colleges in 2016 through a Career Pathways Trust grant funded by the California Community College Chancellor's Office. (OSU, 2016)

However, there are still few studies using DACUM to analyze occupations documented in literature. This article aims to add to the published body of knowledge by reporting on the DACUM process employed to identify sustainable construction technologist competencies. The process included a survey to validate the DACUM results and an analysis using college curriculums and DACUM results to help identifying possible gaps.

Chapter 3

METHODOLOGY

Figure 1 illustrates the methodology used in this study. First, sustainable construction jobs and required skills and knowledge for these jobs were identified through an examination of published job profiles. A literature review was also performed to better understand methodologies used for identifying industry requirements. Base on this review, a time- and cost-effective method with a direct viewpoint of the professionals working in the industry was selected. The review of job profiles and the literature review provided the necessary background to successfully complete the rest of the study methodology. An occupational job analysis approach (DACUM) was used to identify the necessary duties, tasks, and skillsets required to successfully work in a sustainable construction technology position. After the DACUM was complete, a survey was conducted to validate the DACUM results, and 13 experienced professionals who work in high-ranking construction company positions responded to the survey questions. Finally, existing curricula from 2-year programs and certificate programs in sustainable construction management and engineering in the US were reviewed to identify the gaps between the required skills (identified through DACUM) and the skills currently taught in 2-year programs or certificate programs. The gap analysis was conducted by mapping the occupation tasks, skills, and competencies to the existing community college curricula. Based on the data analysis, recommendations are made to better meet industry requirements in community colleges for sustainable construction technology curricula.

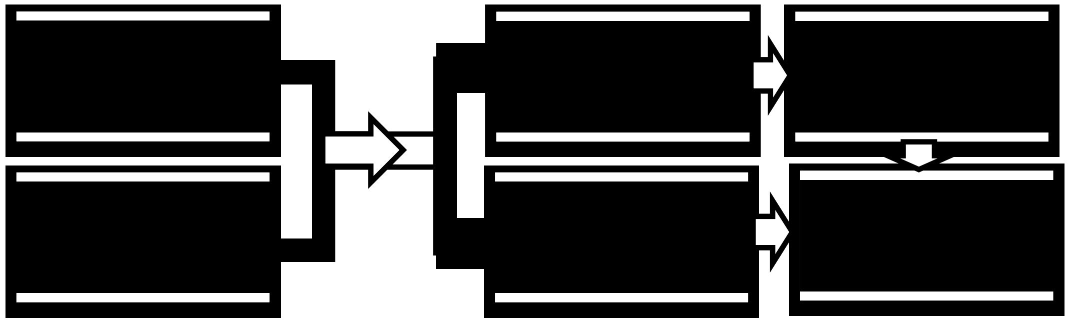

Figure 1. Study Methodology

5. DACUM Job Analysis

DACUM is a structured brainstorming process to identify a specific job's skillsets. A panel of five to nine expert workers in the industry, a competent and trained DACUM facilitator, and a recorder participate in the process. The results from a DACUM analysis include an in-depth representation of the skills and competencies of the study's occupation. DACUM analysis has been used in several aspects of education, training, and certification programs including curriculum development, student learning, training needs assessments, worker performance evaluations, and competency. (Owens et al., 2013)

The value of a DACUM analysis relies on the following assumptions:

- Experts are the ones that can describe their job/occupation better than anyone else.
- It is more effective and precise for experts who perform in the position to define the job/occupation by tasks.
- To perform all tasks correctly, specific knowledge, skills, and tools are required. (Norton, 1997)

Some of the advantages of the DACUM process are group interaction, energized brainstorming power, group synergy, group consensus, superior quality, low cost, and a future-oriented, comprehensive outcome. DACUM has been proven to be a very effective method for quickly determining, at relatively low cost, the competencies or tasks that must be performed by persons employed in a given job or occupational area (Norton, 1997). In addition to these DACUM advantages, DACUM can be used as a method to effectively conceptualize future occupations. That is the case for this study, where I am attempting to define a relatively new occupation – Sustainable Building Technologist.

For this study, a trained facilitator led the DACUM analysis and brought together subject-matter experts in the area of sustainable construction technology. The DACUM consisted of a two-day workshop with the purpose of providing input about the specific tasks, knowledge, and skills needed to perform a sustainable construction technology job.

Figure 2**Error! Reference source not found.** presents the two-day DACUM workshop process followed in this study. The facilitator role was vital to describe the process to the participants and guide them through finding the tasks using suitable wording. The tasks needed to start with active verbs and be easy enough to be understood by the general audience. The brainstorming process included experts suggesting a variety of duties applicable for the position, statement correction by the facilitators, and voting for unanimous agreement over selecting the most suitable duties to obtain the consensus of the group. The same process was adopted for task selection.

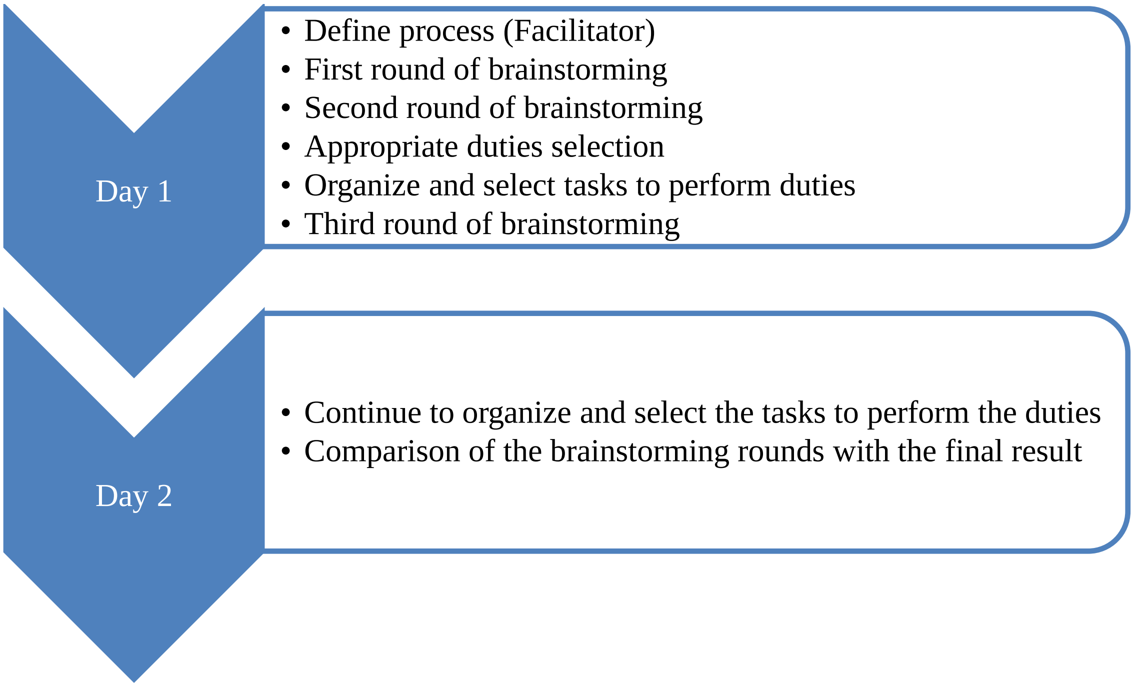

Figure 2. Two-day DACUM workshop process

6. DACUM Validation Survey

The results of the DACUM analysis were validated through a survey. The targeted population of this survey was sustainable construction professionals. A group of 13 participants responded to the pilot survey for this study. A follow-on survey had 40 respondents. The surveys were conducted under a protocol approved by the UNM IRB ID 881334-2. The validation survey consists of three major sections:

- Section 1: includes optional questions regarding participants' information including their gender, years of experience, expertise, ethnicity, and race.
- Section 2: asks the participants to determine the level of importance for each identified task identified in DACUM chart to successfully perform the sustainable construction technology position based on their experience. A five-point Likert scale - (1) not important, (2) neutral, (3) slightly important,

(4) important, and (5) very important is adopted to calculate the relative importance of each identified task.

- Section 3: asks the participants to clarify if, and to what extent, the task can be taught in a class or on the job - multiple terms / entire semester / one assignment and with constant supervision / little supervision.

The responses to section 1 indicate that the participants' occupations include eight architectures/designers, two construction mangers, two engineers, and one specified in other occupations. Five females and eight males with the average of 13 years of experience participated in the validation process.

Sixteen tasks were excluded throughout the survey process because they were classified as personal-professional development opportunities rather than task-specific skills needed by the person to be hired for this position. Table 2 shows the excluded tasks from the validation process.

Table 2. Excluded tasks for the entire validation process

Code	Task
A.18	Distribute project team contact and correspondence list
A.19	Participate in project team meetings
A.20	Prepare project team meeting minutes
D.13	Maintain O & M and project team points of contact
E.4	Develop personal professional development plan
E.5	Complete professional certifications (e.g., LEED GA, BOC, CDT)
E.6	Participate in continuing education activities

E.7	Facilitate continuing education activities
E.8	Compile list of company best practices
E.9	Participate in professional organizations
E.10	Participate in mentoring activities
E.11	Participate in conferences and trade shows
E.12	Facilitate community outreach activities
F.5	Participate in staff meetings
F.6	Establish personal performance deliverables
F.7	Document time and daily activities

The Relative Importance Index (RII) method was first used to determine the relative importance of different causes and effects of delays(Kometa et al. 1994). It was adopted in this study to analyze the data from the second section of the survey and to evaluate the importance of each task in performing the duties of the position successfully. The RII is defined as:

$$RII = \frac{\sum W}{A \times N}$$

where W is the weight given to each factor by the respondents and ranges from not important (1) to very important (5); A is the highest weight (i.e., 5); and N is the total number of respondents (Sambasivan & Soon, 2007), which in this case varies for each question, based on the number of responds, from 8 to 13. These rankings made it possible to cross-compare the relative importance of the tasks as recognized by the respondents.

Weighted average method was used to determine the importance threshold of the responses. Based on Likert scales defined earlier as (1) not important, (2) neutral, (3) slightly important, (4) important, and (5) very important, the threshold to separate the most important tasks was defined at 4.

$$Weighted\ Average = \frac{\sum W}{N}$$

where the W and N have the same definition of RII equation.

In section 3, the responses are classified into two main categories: if performing the task can be learned in the job position (constant supervision / little supervision) or if it can be learned in the college (in a class - multiple terms / entire semester / one assignment). This classification is used to determine how important it is for a college to include teaching a specific skill in its curriculum, according to industry practitioners. In this section, the remaining tasks included in the "participate in professional development activities" phase were excluded, since they were a personality trait and not applicable to be learned as a skill, which includes participating in code update training (E-01), participating in BIM related software training (E-02), and assisting with smart technology feasibility studies (E-03).

7. Existing Curriculum Review

There are more than 1,100 community colleges (CC), with more than 12.4 million enrolled students, serving almost half of all undergraduate students in the US (AACC, 2018). Given that the scope of this paper encompasses the skills of the sustainable construction technology position, I considered community colleges to be the most appropriate educational institutions for providing this type of education and training. Therefore, community college programs were the focus of a review of the existing curriculum to try to identify gaps between the skillset identified through the DACUM process and the skills taught in sustainable construction programs. A comprehensive search on community colleges offering sustainable construction, sustainable building technology, or sustainable management programs with either certificate or 2-year associate degree programs was performed. Overall, more than 20 community colleges with similar programs were identified. Thirteen community colleges were selected for analysis because they provided their curriculum and course details in their catalogs or on their websites. The curriculum review included in-depth and comprehensive reviews of the course details provided by the programs' catalogs, which explain specific knowledge and expertise being taught by taking that course.

8. Gap Analysis

The purpose of the gap analysis was to identify gaps between the necessary skillset identified through the DACUM process and the curricula and courses offered at community colleges in the area of sustainable construction technology. A spreadsheet was developed that mapped the course details to the DACUM results to identify how the current curricula were covering the industry requirement and expectations for sustainable construction technology positions. The gap analysis was conducted using the course details, results of the validation survey, and tasks' importance and how they can be learned.

Chapter 4

RESULTS

1. DACUM Analysis

In this study, the panel selection for the DACUM process was a challenge. Ideally, a DACUM panel would consist of workers who are doing the job for which the curriculum is meant to be developed. Since this study is ahead of the industry in trying to define a middle-level occupation, the higher-level employees' idea who might employ these people were selected. A combination of architects involved with LEED, building energy consultants, and trades workers who are involved in the actual installation of building energy systems were identified and selected. Because Advisory Committees exist at Central New Mexico Community College (CNM) in many of the trades areas and architecture, contacts and networking started from there.

After panel selection, a two-day Job/Task Analysis (JTA) workshop was held at CNM, Albuquerque, New Mexico, on November 9–10, 2016. Three architects (including a LEED fellow), a sustainability project manager, a training director, a BIM director, a BIM specialist, an electrical/PV contractor, and a principal engineer from different companies participated in the DACUM process. Two competent and trained DACUM facilitators moderated the meetings.

The first day of the meeting consisted of an introduction to the DACUM process. A trained facilitator explained the DACUM Job Task Analysis (JTA) process to the participants and provided the panel a sample of DACUM results to better define the duty and task statement. A duty covers a large area of work for a particulate position and includes multiple tasks to perform it. Five duties were identified as the main body of being excel and competent in the sustainable construction technology position: (A) perform pre-construction phase activities, (B) perform construction phase activities, (C) perform post-construction phase activities, (D) perform operations and maintenance activities, (E) participate in professional development activities, and (F) perform administrative tasks. Each duty consists of several tasks that were represented by the codes defined earlier. Overall, 60 tasks were identified to perform effectively in the position (Appendix 1). Table 3 presents the general skills and knowledge required to perform the job as reported in the DACUM results.

Table 3. General knowledge and skills identified in DACUM process to perform green construction technologist responsibilities

General Knowledge and Skills
Computer Skills:
• Spreadsheets
• Apps
• Internet research
• Microsoft Office type tools
• Data (obtain, organize)
• Multi-device and media aptitude
Electronic communication protocol (e.g., email vs. texts)
Knowledge of design and construction industry General knowledge of construction trades Technical writing
Basic understanding of building science
Ability to read construction documents
LEED GA Certification
OSHA for Construction certification
Energy basics
Construction specification formats
Familiarity with green and energy codes and standards
BOC- Building Operating Certificate
Time management skills
Presentation skills
Functional aspects of landscaping and plant choice
Sustainability theory and philosophy

2. Validation

A survey was conducted to verify the DACUM results. The survey was sent to more than 50 experts affiliated with architecture and/or construction related programs at CNM (e.g., an Advisory Committee member) focused on green and sustainable projects. Overall, 13 experts responded to the survey's questions including 8 architectures/designers, 2 construction managers, 2 engineers, and 1 with another position.

The participants rated the importance of each task to perform in the position from 1 (not important) to 5 (very important). Using the Relevant Importance Index (RII), the most important tasks to be prosperous in the sustainable construction technology position were identified. (Table 4)

Table 4. Relative Importance Index (RII) of the identified tasks

Duties	Codes	Tasks	RII
Perform pre-construction phase activities	A-01	Research building project constraints	0.76
	A-02	Research Authority Having Jurisdiction (AHJ) and applicable codes	0.74
	A-03	Coordinate LEED related activities	0.80
	A-04	Document existing project site conditions	0.78
	A-05	Evaluate site designs	0.60
	A-06	Assist with building energy and daylight models	0.78
	A-07	Perform water use and collection calculations	0.66
	A-08	Research green certifications	0.82
	A-09	Research sustainability grants, tax credits and rebates	0.76
	A-10	Integrate green solutions recommendations into design and BIM documentation	0.87
	A-11	Perform BIM coordination	0.74
	A-12	Assist with selection of green materials and systems	0.80
	A-13	Prepare green materials list	0.84
	A-14	Edit project specifications	0.56
	A-15	Prepare waste management construction plan	0.64
	A-16	Prepare air quality construction plan	0.64

	A-17	Assist with SWPPP coordination	0.76
Perform construction phase activities	B-01	Perform submittal review	0.68
	B-02	Assist with permit process	0.51
	B-03	Distribute commissioning plan and checklist	0.62
	B-04	Verify received materials (at work site)	0.63
	B-05	Track green materials	0.78
	B-06	Assist with coordination of construction trades	0.53
	B-07	Manage construction waste plan	0.70
	B-08	Assist with construction checklist verification	0.77
	B-09	Manage Indoor Air Quality (IAQ) plan	0.70
	B-10	Assist with compliance documentation	0.76
	B-11	Assist with systems performance testing (e.g., HVAC, plumbing, lighting)	0.60
	B-12	Assist with envelope performance testing (e.g., windows, air barrier)	0.63
	B-13	Collect Storm Water Pollution Prevention Plan (SWPPP) event reports	0.68
	B-14	Input facility management systems-related data	0.68
	B-15	Perform flush out calculations	0.50
Perform post-construction phase activities	C-01	Document air quality flush out plan	0.75
	C-02	Update energy management plan	0.73
	C-03	Help coordinate submittal data for Operations & Maintenance (O&M) manuals	0.80
	C-04	Compile construction phase report for commissioning agent (e.g., substantial completion, record drawings, Test and Balance report)	0.65
	C-05	Upload documents to LEED online	0.80
	C-06	Update standards with lessons learned (e.g., company owner)	0.65
	C-07	Implement green signage	0.68
	C-08	Establish O & M points of contact	0.70
	C-09	Document building performance goals	0.70
Perform Operations and Maintenance (O & M) activities	D-01	Train O & M staff in green practices (e.g., soap, cleaning supplies)	0.65
	D-02	Track utility performance (e.g., gas, water, electrical)	0.75
	D-03	Report actual building occupancy	0.70
	D-04	Set up data loggers	0.63
	D-05	Validate Energy Management System (EMS) set points	0.68
	D-06	Educate occupants on building sustainability plan	0.73

	D-07	Oversee building recycling plan	0.70
	D-08	Verify use of green consumables	0.70
	D-09	Conduct building sustainability performance review	0.68
	D-10	Maintain list of building performance related issues	0.68
	D-11	Maintain LEED compliance documents	0.75
	D-12	Assist with third party audits	0.65
Participate in professional development activities	E-01	Participate in code update training	0.80
	E-02	Participate in BIM related software training	0.91
	E-03	Assist with smart technology feasibility studies	0.78
Perform administrative tasks	F-01	Maintain green product library	0.78
	F-02	Assist with development of materials to market green practices	0.71
	F-03	Identify green marketing opportunities	0.69
	F-04	Maintain standard green specifications	0.82

The RII varies from 0.50 to 0.91, which is a wide range to consider. For each duty, the average RII of associated tasks was calculated and shown in Figure 3. The most important duty with RII of 0.83 was "Participate in Professional Development Activities" (E) implying the importance of self-development in the position for an employee in a sustainable construction technology occupation. Duty F (perform administrative tasks) was the second important duty to perform for this job since it is a middle-level position and the employee needs to perform activities to connect the higher level position to the entry level ones. Pre-construction phase activities (A) needs to take more priority than construction (B) and post-construction phase activities (C). Construction phase activities (B) was identified as the least important duty, while it is believed that most of the construction activities are being done during the construction phase. This result suggested that the defined middle level position requires more knowledge and skill relevant to pre and post construction activities to support the manager-labor interactions.

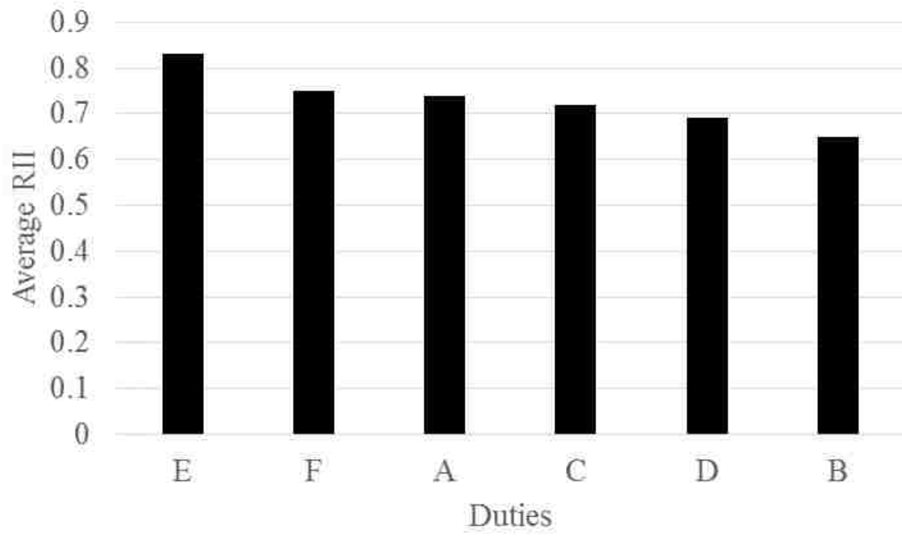

Figure 3. Duties priority based on relevant importance index

The tasks were sorted based on RII and weighted average values separately and the results provided the same order for all tasks. The most critical tasks were selected with the weighted average higher than 4 (same as RII>0.8), suggesting tasks that were in the highest priority about which graduates should have knowledge with the highest level of importance.

(Figure [redacted] [redacted] 4)

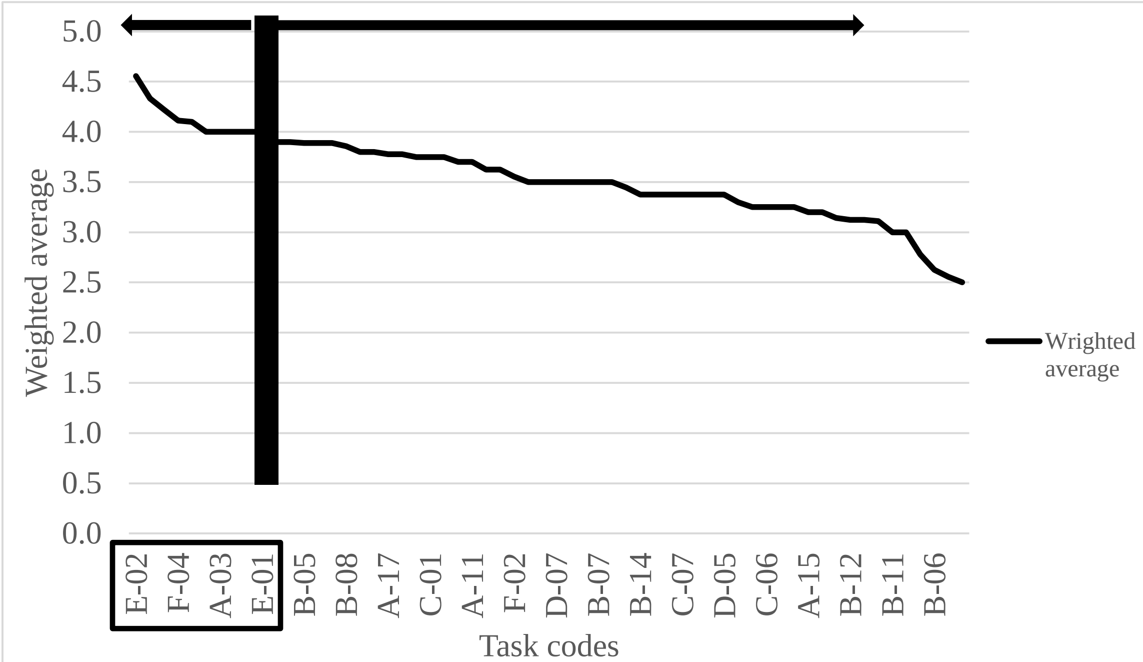

Figure 4. Identified tasks sorted by the weighted average values

Figure 5 illustrates that tasks E-02 (participate in BIM related software training), A-10 (integrate green solutions recommendations into design and BIM documentation), A-13 (prepare green materials list), F-04 (maintain standard green specifications, A-08 (research green certifications), C-05 (upload documents to LEED online), A-03 (coordinate LEED related activities), A-12 (assist with selection of green materials and systems), and C-03 (help coordinate submittal data for Operations & Maintenance (O&M) manuals) are among the most critical tasks, in that order. BIM related knowledge tasks were identified as the most important tasks in the sustainable construction technology position. Knowledge linked to green construction and LEED were among the most important tasks after the BIM area, which suggests that in a sustainable/green position, the information regarding sustainability would be more highlighted and requires extra consideration in training, either in the job position or at a college.

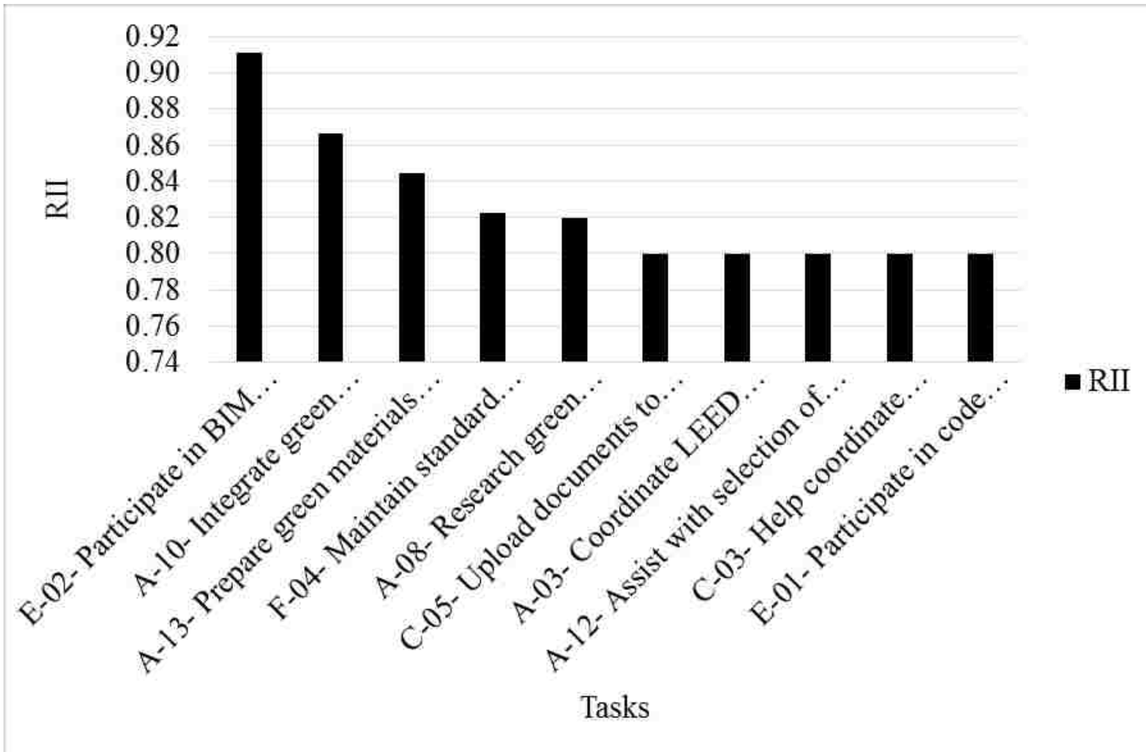

Figure 5. The most important tasks based on both RII and weighted average

The last section of the survey asks the participants if an employee in the sustainable construction technology position can learn how to perform the identified task in the job with supervision/experience or at college. This question is essential to realize how important it is for the colleges to include the required knowledge in their curriculum. (Figure 6)

The tasks E-01 (Participate in codes update training) and E-02 (Participate in BIM related software training) were excluded from this section since they are tasks in the "participate in professional development activities" duty category that can only be learned by being in the position and experiencing it. Figure 6 argues that nearly all of the most important tasks require job supervision more than learning in college. For instance, 73 percent of professionals identified A-10 (integrate green solutions recommendations into design and BIM documentation) as a task that can be learned in the job position, while only 27 percent admit that it can be learned in college. However, half of the participants consider that C-05 (Upload documents to LEED online) can be learned either in college or in the position. Tasks A-13, F-04, A-03, and A-12 are roughly receiving the same rate of being learned at college or in the job position, which means that if they were included in the curriculum, there would be less training time required at work.

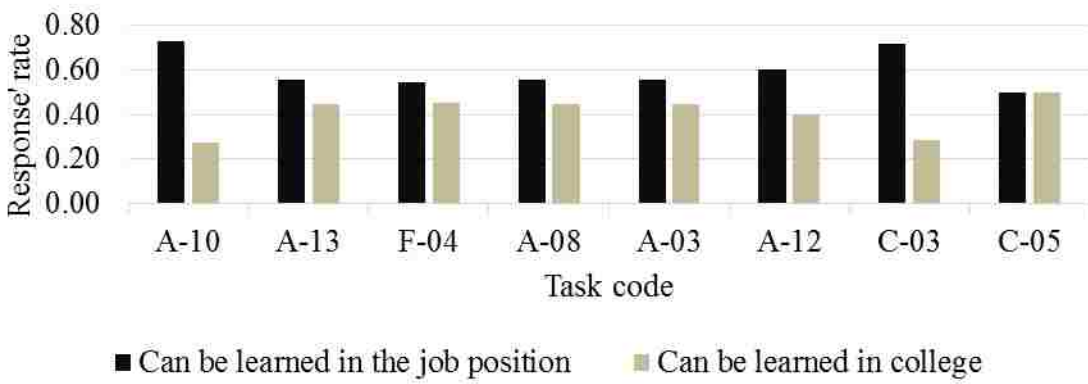

Figure 6. Comparison between important tasks being learned in either college or the position

3. Curricula Review

An in-depth study of current curricula offered by Community Colleges in the area of sustainable construction is conducted to recognize academia's offered knowledge in sustainable construction programs. Thirteen community colleges and 14 programs in the US with green/sustainable construction/building technology curriculum including certificate programs, two-year associate degree, and bachelor's degree were studied (Table 55). The number of credits were different depending on the type of degree/certification a college offers.

Table 5. College sustainable construction programs

College name, state	Program name	Degree	Number of credits	Reference
Erie CC[1], NY	Green Building Technology	Certification	31	https://www.ecc.edu/
Bristol CC, MA	Green Building Technology	Certification	22/23	http://www.bristolcc.edu/
Rockland CC, NY	Green Building	Certification	30	http://www.sunyrockland.edu/
Aims CC, CO	Green/Sustainable building	Certification	8	http://www.aims.edu/
Bergen CC, NJ	Green Construction Management	Certification	230	https://bergen.edu/
Hawkeye CC, IA	Sustainable Construction and Design	AAS[2]	69	https://www.hawkeyecollege.edu/
Mott CC, MI	Sustainable Construction	Certification	15	http://mcc.edu/
Technical College of the low Country, SC	Green Residential Construction Management	Certification	19	https://www.tcl.edu/
North Seattle CC, WA	HVAC/Sustainable Building Engineering Technician	AAS	92	https://www.northseattle.edu/
De An Za College, CA	Facility and Sustainable Building Management	Certification	21	https://www.deanza.edu/
Santa Barbara City College, CA	Construction Technology	Certification	33-35	http://www.sbcc.edu/
Santa Barbara City College, CA	Construction Technology	AAS	41	http://www.sbcc.edu/
South Seattle CC, WA	Sustainable Building Science Technology	BAS[3]	90	http://www.southseattle.edu

[1] Community College
[2] Associates in Applied Science
[3] Bachelor of Applied Science

Central New Mexico Community College, NM	Sustainable Building Technology	Certification	19-25	https://www.cnm.edu

Figure 7 shows the Community Colleges with sustainable construcion programs in the US that were evaluated for this study. There are 2 colleges in the state of California, 2 colleges in the state of New York, and one college in several other states as indicated by the highlighted states.

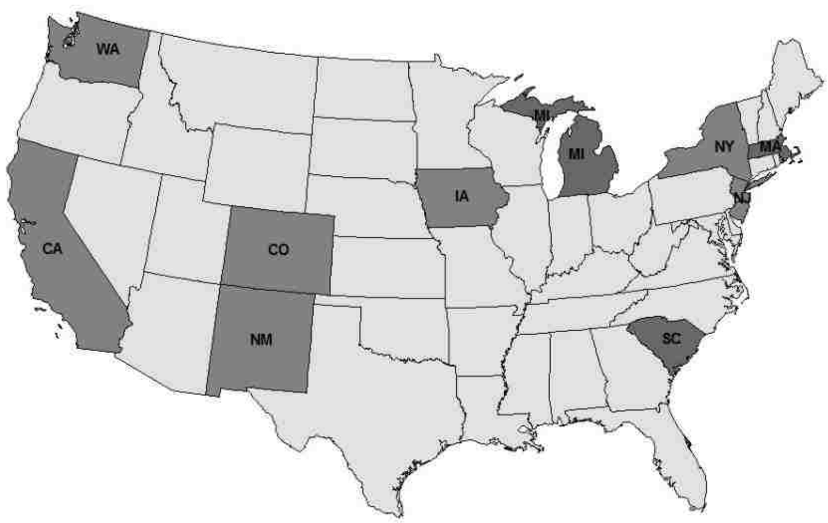

Figure 7. US map with the selected Community Colleges

4. DACUM Survey Mapping with Curriculum

Course details were collected from colleges' online catalogues and studied in depth to map the courses with the identified tasks in the DACUM results. For example, the "Green Building Materials" (GRB 140) course in Rockland Community College objectives' include "both the selection and specification processes for green building materials. Environmentally preferable purchasing guidelines related to cleaning, maintenance, and other materials and supplies are also covered". This description could possibly imply that when passing the Green Building Materials course, a student will be able to perform the following tasks: A-16 (prepare green materials list), A-15 (assist with selection of green materials and systems), B-4 (verify received materials), and B-5 (track green materials). The in-depth review of each course description provided a database to map the learning objectives of a course with the industry-expected competencies.

The purpose of this section is to determine if colleges are addressing the industry-requirements for middle-level sustainable construction positions in their curriculum. **Error! Reference source not found.**6, specifies that task A-15 ("assist with selection of reen materials and systems" task) is addressed in 11 specific and different courses offered in 10 community colleges.

Table 6. Mapping A-15 (Assist with selection of green materials and systems) task with offered curriculum in Community Colleges

College name	Course number- Course name
Hawkeye CC	CON 217- Exterior Finishing
Santa Barbara City College	CT 120- Building Green
De An Za CC	E S 58- Introduction to Green Building
Erie CC	BM 225- Energy Management
Bristol CC	EGR 123- Green Building Practices
Rockland CC	GRB 140- Green Building Materials
CNM	CM 1110- Construction Materials and Techniques
South Seattle CC	SBST 322- Energy Analysis & Auditing
Mott CC	BCON 201- Green Construction BCON 181- Construction Materials
Aims CC	ENY 153- Renewable Energy Construction

5. Gap Analysis

From the most important tasks identified in Figure 4, the gap analysis identified E-02 (participate in BIM related software training), A-10 (integrate green solutions recommendations into design and BIM documentation), and A-13 (prepare green materials list) as the topics not covered by college programs (Figure 8). Knowledge in BIM, as a relatively recent knowledge introduced to construction academic programs, was expected from a graduate in sustainable construction technology.

F-04 (maintain standard green specifications), A-08 (research green certifications), and A-12 (assist with selection of green materials and systems) were green related tasks that, despite of their importance and relevance to sustainable construction education, were not discussed or mentioned in curricula. While E-01 (participate in code update training) was the 8th most important task, it was not considered as a task to be learned in a college, since participating in work training was a task which requires only work expertise and experience.

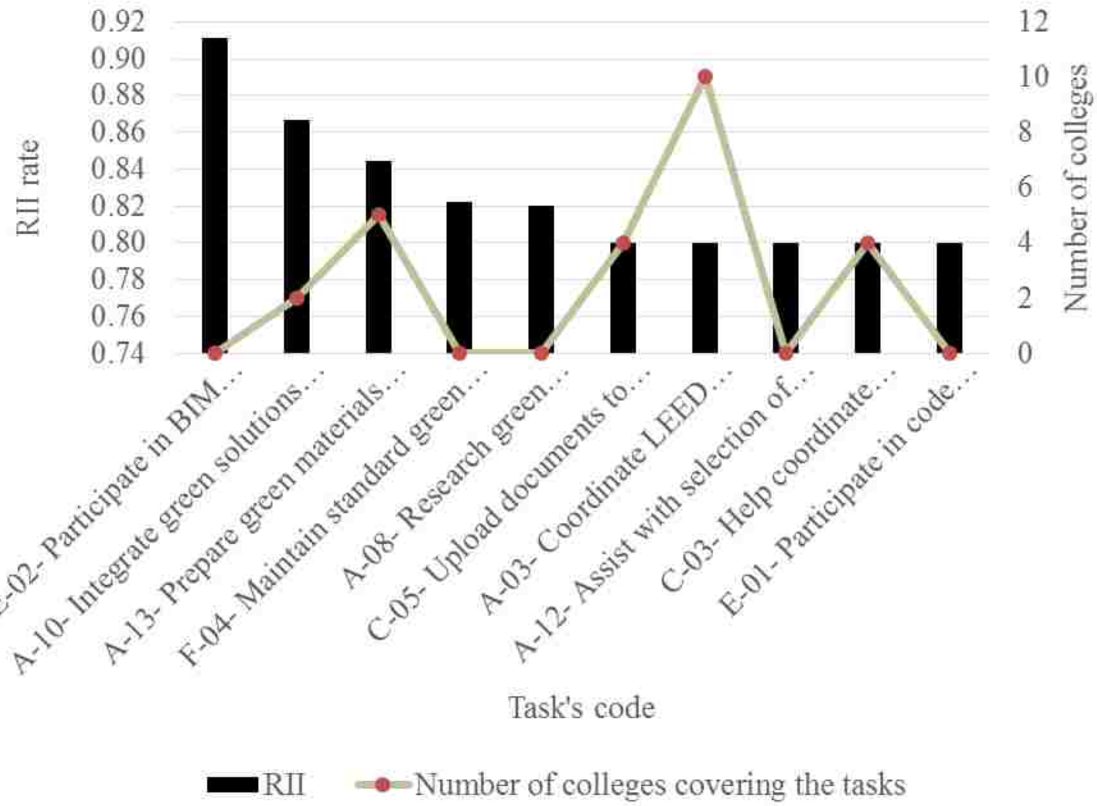

Figure 8. The most important tasks vs. colleges covering them in their curriculum

Table 7 shows the most important tasks with respect to the highest number of participants chosen tasks that can be learned at college. The purpose of this table is to show to what extent the tasks that most likely can be learned at college are covered by the college curriculums. A detailed examination of Table 7 reveals some of the specifics of the gap between what industries expect and what colleges teach.

Table 7. Prioritized tasks, sorted by their rate of being learned at college

Codes	Identified tasks	Can be learned in the job position (Rate)	Can be learned in college (Rate)	Number of colleges covering the tasks
C-05	Upload documents to LEED online	0.50	0.50	4
F-04	Maintain standard green specifications	0.55	0.45	0
A-13	Prepare green materials list	0.56	0.44	5

A-08	Research green certifications	0.56	0.44	0
A-03	Coordinate LEED related activities	0.56	0.44	7
A-12	Assist with selection of green materials and systems	0.60	0.40	10
C-03	Help coordinate submittal data for Operations & Maintenance (O&M) manuals	0.71	0.29	0
A-10	Integrate green solutions recommendations into design and BIM documentation	0.73	0.27	2

Task A-12 (assist with selection of green materials and systems) is identified as one of the most important tasks to perform the job with a high possibility of being learned in college. Ten colleges include teaching it in their curriculum. This task shows an excellent match between the industry-requirement and college curriculum. Also, task A-03 (coordinate LEED related activities) is among the most addressed in college curriculums with 7 colleges offering it. However, many tasks are not covered or poorly covered; only a few colleges include them in their program and curriculums. Task F-04 (maintain standard green specifications), A-08 (research green certifications), and C-03 (help coordinate submittal data for Operations & Maintenance (O&M) manuals) are not addressed in any of the studied syllabi. (Figure 9)

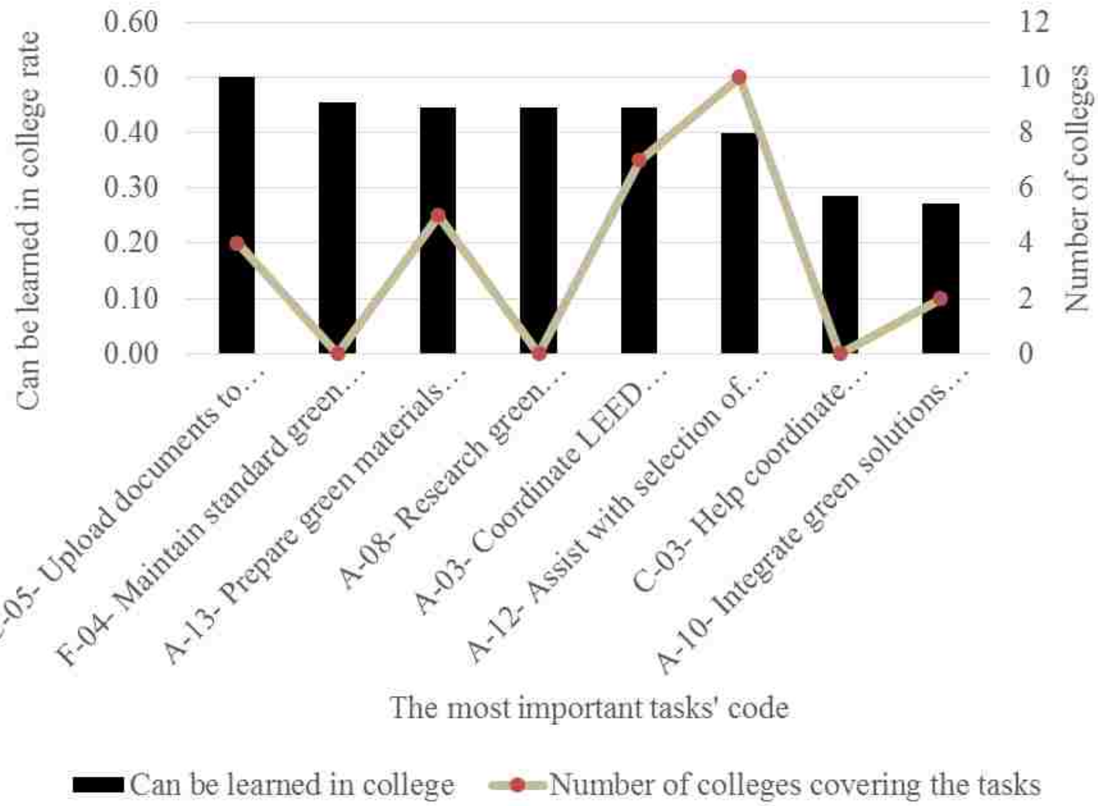

Figure 9. Tasks potentially being learned in college vs. colleges covering them in their curriculum

Figure 10 Figure 10 illustrates the existing gap between knowledge and tasks (competencies) that can be learned on the job with supervision and the number of colleges addressing them in their program. Six colleges cover task B-05 (track green materials) while it is a task that can be supervised and learned on the job. Also, B-04 (verify received materials) is addressed by 8 colleges, however experts highly recognize it as a task that can be learned on the job position. F-01(maintain green product library), A-01(research building project constraints), and F-02 (assist with development of materials to market green practices) are the tasks that are not covered in any of the studied curricula, implying that colleges are not addressing the tasks that are easy to learn how to perform on the job, which indicates the strong industry-curriculum match.

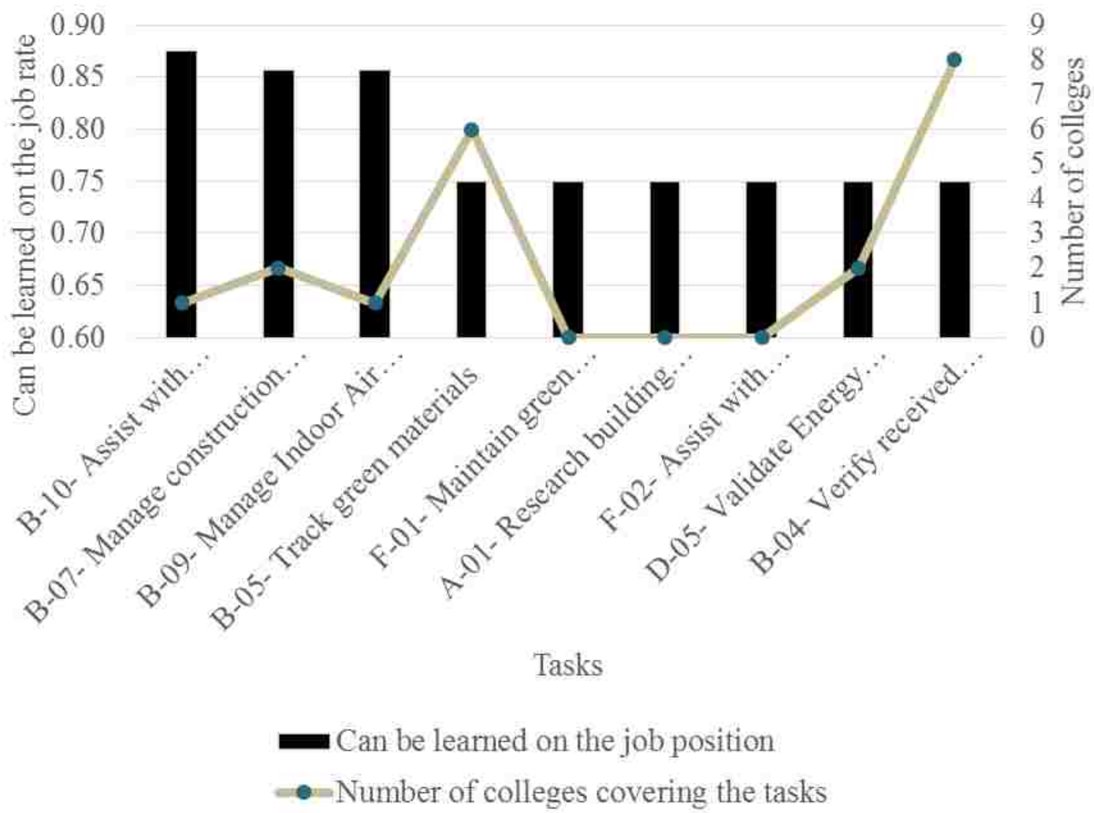

Figure 10. Tasks being learned in job vs. colleges covering them in their program

The most significant gaps in the area of sustainable construction technology is found in F-04 (maintain standard green specifications), A-13 (Prepare green materials list), and A-08 (research green certifications). Although A-10, integrate green solutions recommendations into design and BIM documentation, is the most important task, it is not among the high rates of being learned in college and consequently is not covered well in the college programs. However, it is expected that with exceeding large number of colleges offering BIM related courses, industry experts would consider it as a task to be learned more in a college than in a job position.

CONCLUSION

With the constant increase in the sustainable construction market and its substantial economic impact in the US in conjunction with fast technological development, educators need to provide appropriate curriculum materials to continue bridging the gap between industry requirements and educational perceptions. Using job advertisement reviews and a job analysis method (DACUM), 6 categories including (1) perform pre-construction phase activities, (2) perform construction phase activities, (3) perform post-construction activities, (4) perform Operations and Maintenance (O & M) activities, (5) participate in professional development activities, and (6) perform administrative tasks were identified. Overall, 60 tasks were identified to perform successfully in the position. Verification survey results indicate that the most significant tasks in the sustainable construction technology position were participating in BIM related software training, integrating green solutions recommendations into design and BIM documentation, preparing the green materials list, and maintaining standard green specifications. BIM related skills were implied to be the most critical practical knowledge in the sustainable construction technologist position.

Among the most significant tasks, only a few have the potential to be learned in the college including C-05 (upload documents to LEED online) and F-04 (maintain standard green specifications). However, most of the tasks were identified to be learned better and more suitable in the job position than in college.

Thirteen community college curricula reviews, coupled with mapping the courses' descriptions with DACUM verified results, provided a proper tool to compare the industry-expected competencies to the offered curricula in academia. Among the most significant identified tasks that can be learned in the college, the highest gap was found in task F-04 (maintain standard green specifications), A-08 (research green certifications), and C-03 (help coordinate submittal data for Operations & Maintenance (O&M) manuals) which are not addressed in any of the studied syllabi. Tasks that can be learned in the job and are significantly offered in the colleges indicate a different type of existing gap. Tasks B-05 (track green materials) and B-04 (verify received materials) are more applicable to be learned in the job position.

Based on the existing identified gaps, this study suggests that academia requires continually updating the fast-track technology programs' materials and adopting the industry requirements more frequently. More specifically, BIM and LEED related skills need to be represented more strongly in the curricula while verifying and tracking green material can be represented less strongly.

Since the data is collected from sustainable construction industry and academia – community colleges – in the US, the applicability of this study outside the US is not presently confirmed and needs to be investigated in future studies. However, considering the curricula standard similarities and pace of technological development in sustainable construction, this study provides valuable information and methods for other institutions to adopt. In addition, only 13 experts from the industry verify DACUM results; therefore, the survey needs to be expanded for future work to more clearly represent the industry perspective.

Appendix A

DACUM Results for Sustainable Construction Technologist

Table 8. DACUM research chart for sustainable construction technologist

Duties	Tasks			
A. Perform Pre-Construction Phase Activities	A.1 Research building project constraints	A.2 Research AHJ and applicable codes	A.3 Coordinate LEED related activities	A.4 Document existing project site conditions
	A.5 Evaluate site designs	A.6 Assist with building energy and daylight models	A.7 Perform water use and collection calculations	A.8 Research green certifications
	A.9 Research sustainability grants, tax credits and rebates	A. 10 Integrate green solutions recommendations into design and BIM documentation	A.11 Perform BIM coordination	A.12 Assist with selection of green materials and systems
	A.13Prepare green materials list	A.14 Edit project specifications	A.15 Prepare waste management construction plan	A.16 Prepare Air Quality Construction Plan
	A.17 Assist with SWPPP coordination	A.18 Distribute project team contact and correspondence list	A.19 Participate in project team meetings	A.20 Prepare project team meeting minutes
B. Perform Construction Phase Activities	B.1 Perform submittal review (products, equipment, systems)	B.2 Assist with permit process	B.3 Distribute commissioning plan and checklist	B.4 Verify received materials
	B.5 Track green materials	B.6 Assist with coordination of green trades	B.7 Manage construction waste plan	B.8 Assist with construction checklist verification
	B.9 Manage IAQ plan	B.10 Assist with compliance documentation	B.11 Assist with systems performance testing (e.g., HVAC, plumbing, lighting)	B.12 Assist with envelope performance testing (e.g., windows, air barrier)
	B.13 Collect SWPPP event reports	B.14 Input facility management systems-related data	B.15 Perform flushout calculations	

C. Perform Post-Construction Phase Activities	C.1 Document air quality flushout plan	C.2 Update energy management plan	C.3 Help coordinate submittal data for O & M manuals	C.4 Compile construction phase report for commissioning agent (e.g., substantial completion, record drawings, T & B report)
	C.5 Upload documents to LEED online	C.6 Update standards with lessons learned (e.g., company owner)	C.7 Implement green signage	C.8 Establish O & M points of contact
	C.9 Document building performance goals			
D. Perform O & M Related Activities	D.1 Train O & M staff in green practices (e.g., soap, cleaning supplies)	D.2 Track utility performance (e.g., gas, water, electrical)	D.3 Report actual building occupancy	D.4 Set up data loggers
	D.5 Validate EMS set points	D.6 Educate occupants on building sustainability plan	D.7 Oversee building recycling plan	D.8 Verify use of green consumables
	D.9 Conduct building sustainability performance review	D.10 Maintain list of building performance related issues	D.11 Maintain LEED compliance documents	D.12 Assist with third party audits
	D.13 Maintain O & M and project team points of contact			
E. Participate in Professional Development Activities	E.1 Participate in code update training	E.2 Participate in BIM related software training	E.3 Assist with smart technology feasibility studies	E.4 Develop personal professional development plan
	E.5 Complete professional certifications (e.g., LEED GA, BOC, CDT)	E.6 Participate in continuing education activities	E.7 Facilitate continuing education activities	E.8 Compile list of company best practices
	E.9 Participate in professional organizations	E.10 Participate in mentoring activities	E.11 Participate in conferences and trade shows	E.12 Facilitate community outreach activities
	F.1 Maintain green product library	F.2 Assist with development of materials to	F.3 Identify green marketing opportunities	F.4 Maintain standard green specifications

F. Perform Administrative Tasks		market green practices		
	F.5 Participate in staff meetings	F.6 Establish personal performance deliverables	F.7 Document time and daily activities	

Tools, Equipment, Supplies, and Materials knowledge that are beneficial to know include airflow hood, azimuth tool, augmented reality tools (e.g., Daqri), blower door, cell phone, cell phone apps, CO2 sensor, data loggers, duct blaster, infrared scanner, laser level, light meter, measuring tools (e.g., tape measure), solmetric sun eye, sUAS, tablet-based applications, and temperature sensor.

Expected behaviors for graduates to be detail oriented, collaborative, analytical, punctual, observant, self-motivated, perseverance, confident, respectful, professional attire, initiative, and passion for sustainability.

Future Trends and Concerns

- Resistance to green materials and systems
- Financing mechanisms not set up to accommodate long range thinking
- Tax Credits availability
- Economic growth and stability
- Lack of skilled labor
- Diminishing vocational education opportunities in high school
- Resource depletion
- Climate change
- Increasing energy costs
- Increasing water costs

- Adoption of future Technology
- Initial cost of green energy systems
- Automated data analysis
- Cyber security
- Failure to integrate sustainability into design
- Changing code requirements
- Need lobbying for green/renewable energy
- Pre-fabricated/modular construction techniques
- Additive manufacturing
- Integration of augmented reality with construction practices
- Smart technology to collect data on resource consumption

Recommendations

- Offer construction technology course in high school
- Community outreach and education on the cost to benefit of green adoption (high school teachers should be educated).
- Lobby for green/renewable energy
- Press releases/social media on progress of certificate and project development
- Proof studies on the benefits of green construction
- Before and after cost comparison
- Life cycle
- Publicize green efforts to create a buzz
- Leverage Campus as a Living Lab

- Collaborate/partner with local employers to train students (volunteers, as part of course/program
- Mandatory participation in USGBC student group
- Encourage students to join student level of professional groups
- Collaborate with UNM programs
- Take field trips
- Conduct audits on their own buildings (homes, apartments, etc.)
- Students create learning modules and learning materials
- Identify green related projects that were started in schools and complete them, e.g., project where each public school's roof is assessed for how much solar power it could generate. Create a map that would show how many housing units/buildings in the immediate vicinity of the school could be powered with the solar generated energy.

Appendix B

Mapping DACUM Results to Community Colleges' Course Descriptions for Sustainable Construction Technology

Table 9. Pre-construction phase activity tasks mapped with the courses offered by the colleges

Tasks	College. Course code				
A.1 Research building project constraints	Ha. CON-102				
A.2 Research AHJ and applicable codes	Ha. CON-512	De. E S 81	Er. BM 130	So. SBST 321 & SBST 332	Mo. BCON-201 BCON-182
A.3 Coordinate LEED related activities	De. E S 58	Ha. CON-214	Er. BM 225	So. SBST 322	CM. CM 1233
	Be. CD 494	Ai. ENY 205			
A.4 Document existing project site conditions	Ha. CON-131	Be. CD 125	Te. CT 127	Ro. GRB 110	
A.5 Evaluate site designs	CM. CM 1233				
A.6 Assist with building energy and daylight models	Ha. ENV-155	Er. BM 225	So. SBST 402 SBST 322 SBST 302	CM. CM 2230	Be. CD 116
	Ro. GRB 130	So. CT 122			
A.7 Perform water use and collection calculations	Er. BM 266	Mo. BCON-201	Be. CD 512	Ro. GRB 110	So. CT 122
A.8 Research green certifications					
A.9 Research sustainability grants, tax credits and rebates					
A.10 Distribute project team contact and correspondence list					
A.11 Participate in project team meetings					
A.12 Prepare project team meeting minutes					
A. 13 Integrate green solutions recommendations into design and BIM documentation	CM. CM1205	No. TDR100			
A.14 Perform BIM coordination	CM. CM1205	No. TDR100			

A.15 Assist with selection of green materials and systems	De. E S 58	Ha. CON-217	Er. BM 225	So. SBST 322	Mo. BCON-201 BCON-181
	CM. CM 1110	Sa. CT 120	Br. EGR 123	Ai. ENY 153	Ro. GRB 140
A.16 Prepare green materials list	De. E S 58	Ha. CON-217	Sa. CT 120	Br. EGR 123	Ro. GRB 140
A.17 Edit project specifications	Mo. BCON-180 BCON-268	CM. CM 1105	Te. BCT 230		
A.18 Prepare waste management construction plan	Be. CD 125				
A.19 Prepare Air Quality Construction Plan	Be. CD 116	Ro. GRB 110	Ai. ENY 153		
A.20 Assist with SWPPP coordination					

Table 10. Construction phase activity tasks mapped with the courses offered by the colleges

Tasks	College. Course code				
B.1 Perform submittal review (products, equipment, systems)					
B.2 Assist with permit process	Ha. COM-78	De. BUS 85	Mo. TECH-100		
B.3 Distribute commissioning plan and checklist	Ha. COM-78	De. BUS 85	Er. BM 240		
B.4 Verify received materials	Er. BM 130 BM 225	DE. E S 58	Ha. CON-217	Mo. BCON-201	Sa. CT 120
	Br. EGR 123	Ro. GRB 110 GRB 140	Ai. ENY 153		
B.5 Track green materials	Er. BM 225	Ro. GRB 140	Br. EGR 123	De. E S 58	Sa. CT 120
	Ha. CON-217				
B.6 Assist with coordination of green trades	Ha. COM-781	De. BUS 85			
B.7 Manage construction waste plan	Be. CD 578				
B.8 Assist with construction checklist verification					
B.9 Manage IAQ plan	Be. CD 116	Ro. GRB 110	Sa. CT 122	Ai. ENY 153	
B.10 Assist with compliance documentation	Te. CT 196				

B.11 Assist with systems performance testing (e.g., HVAC, plumbing, lighting)	Te. CT 124	Ro. GRB 210	CN. CM 2230	So. SBST 402	Sa. CT 122-CT 124
B.12 Assist with envelope performance testing (e.g., windows, air barrier)	Mo. BCON-210	So. SBST 322	Ai. ENY 153-ENY 205	Sa. CT 124	Ha. ENV-155
	Be. CD 510				
B.13 Collect SWPPP event reports	Te. CT 196	De. E S 82			
B.14 Input facility management systems-related data	So. SBST 422				
B.15 Perform flushout calculations	CN. CM 2230				

Table 11. Post-construction phase activity tasks mapped with the courses offered by the colleges

Tasks	College. Course code				
C.1 Document air quality flushout plan	Sa. CT 196				
C.2 Update energy management plan	Ro. GRB 130	Er. BM 225	So. SBST 322	Ai. ENY 205	Ha. ENV-155
	Mo. BCON-210				
C.3 Help coordinate submittal data for O & M manuals					
C.4 Compile construction phase report for commissioning agent (e.g., substantial completion, record drawings, T & B report)	Er. BM 240	De. E S 82	Sa. CT 196		
C.5 Upload documents to LEED online	BE. CD 494	De. E S 58	Ha. CON-214	Er. BM 225	
C.6 Update standards with lessons learned (e.g., company owner)					
C.7 Implement green signage	Be. CD 508				
C.8 Establish O & M points of contact					
C.9 Document building performance goals	Sa. CT 122	CN. CM 2230	Te. CT 124		

Table 12. O & M Related Activities tasks mapped with the courses offered by the colleges

Tasks	College. Course code				
D.1 Maintain O & M and project team points of contact					
D.2 Train O & M staff in green practices (e.g., soap, cleaning supplies)					
D.3 Track utility performance (e.g., gas, water, electrical)	De. E S 70	Er. BM 240	Mo. BCON-201	Sa. CT 122	Br. EGR 183
	Be. CD 116 CD 512	Ro. GRB 240 GRB 250			
D.4 Report actual building occupancy	Mo. TECH-100	So. SBST 431	Er. BM 240	De. E S 82	Ha. COM-781
D.5 Set up data loggers					
D.6 Validate EMS set points					
D.7 Educate occupants on building sustainability plan					
D.8 Oversee building recycling plan	Be. CD 578	Mo. BCON-183			
D.9 Verify use of green consumables	Mo. BCON-183				
D.10 Conduct building sustainability performance review	Sa. CT 124	Ro. GRB 250	CN. CM 2230	Mo. BCON-183	
D.11 Maintain list of building performance related issues	Sa. CT 124	Ro. GRB 250	Mo. BCON-183		
D.12 Maintain LEED compliance documents	Er. BM 225	Ha. CON-214	Te. CD 494	Be. E S 58	
D.13 Assist with third party audits	Mo. BCON-210	So. SBST 322	Te. CT 127	Ai. ENY 205	

Table 13. Participate in Professional Development Activities tasks mapped with the courses offered by the colleges

Tasks	College. Course code				
E.1 Develop personal professional development plan					
E.2 Complete professional certifications (e.g., LEED GA, BOC, CDT)	Br. EGR 123	Te. CT 130	Be. CD 494 CD 518		
E.3 Participate in continuing education activities					

E.4 Facilitate continuing education activities					
E.5 Participate in code update training					
E.6 Participate in BIM related software training					
E.7 Compile list of company best practices					
E.8 Participate in professional organizations					
E.9 Participate in mentoring activities					
E.10 Participate in conferences and trade shows					
E.11 Facilitate community outreach activities	De. BUS 85	Ha. COM-781			
E.12 Assist with smart technology feasibility studies					

Table 14. Perform Administrative Tasks mapped with the courses offered by the colleges

Tasks	College. Course code				
F.1 Maintain green product library					
F.2 Assist with development of materials to market green practices					
F.3 Identify green marketing opportunities					
F.4 Maintain standard green specifications					
F.5 Participate in staff meetings					
F.6 Establish personal performance deliverables					
F.7 Document time and daily activities	Te. CT 196 CT 290				

Table 15. Community colleges' abbreviation and courses directory

College Code	College Name	Courses codes and name				
Er.	Erie CC	M 130 - Building Systems I	BM 225 - Energy Management	BM 266 - Green HVAC & Plumbing	BM 240 - Plumbing Systems	BM 240 - Plumbing Systems
Br.	Bristol CC	EGR 123- Green Building Practices	EGR 183- Energy Efficiency			

			and Conservation Measures			
Ro.	Rockland CC	GRB 110 Introduction to Green Buildings	GRB 210 Building Automation and Controls	GRB 130 Energy Management	GRB 240 Care of Green Spaces	GRB 250 Troubleshooting Green Building Systems
Ai.	Aims CC	ENY 205- Green & Sustainable Buildings	ENY 153- Renewable Energy Construction			
Be.	Bergen CC	CD 116 Energy and Sustainability in the Built Environment	CD 512 Water Resource Management	CD 510 Introduction to Building Science & Sustainable High Performance Building	CD 494 LEED Green Associate Exam Prep	CD 125 Construction Site Management
		CD 578 Waste Management & Reduction	CD 508 Introduction to Sustainability	CD 518 Green Advantage® Exam Prep		
Ha.	Hawkeye CC	COM-781 Written Communication in the Workplace	CON-214 Exterior Framing Systems I	ENV-155 Residential Energy Auditing	CON-102- Introduction to Residential Construction	CON-512 Construction Technology Lab
		CON-131- Site Layout and Blueprint Reading	CON-146 Construction Technology Lab 2	CON-217 Exterior Finishing		
Mo.	Mott CC	BCON-183 Bldg Maintenance & Weatherization	BCON-201 Green Construction	BCON-210 Residential Energy Auditing	TECH-100 Communication Skills for Technology	BCON-182 Bldg Construction Codes
		BCON-181 Construction Materials	BCON-180 Construction Fundamentals	BCON-268 Construction Estimating	BCON-268 Construction Estimating	
Te..	Technical College of the lowCountry	BCT 230 – Bidding/Contracts/Specifications				
No.	North Seattle CC	TDR100- Basic BIM for Design & Construction	TDR103- Energy Analysis for BIM	TDR102- Advanced BIM for Design & Construction		

De.	De An Za College	BUS 85 Business Communication	E S 58 Introduction to Green Building	E S 70 Introduction to Energy, Management, and Technology	E S 81 Leadership in Energy and Environmental Design/Sustainability Codes	E S 82 Project Management and Technical Report Writing for Energy Professionals
Sa.	Santa Barbara City College	CT 130: Contractors License Prep	CT 124: Building Performance	CT 196: Jobsite Management	CT 127: Sustainability Audit/CT 196: Jobsite Management	CT 120: Building Green
		CT 290: Work Experience In Construction Trades				
CN.	CNM	CM 2230 Building Energy Analysis	CM 1233 Sustainable Building Practices	CM1205-Introduction to Building Information Modeling	CM 1110 Construction Materials and Techniques	CM 1105 Construction Detailing
So.	South Seattle CC	SBST 322 Energy Analysis & Auditing	SBST 402 Lighting	SBST 321 Building Codes	SBST 332 Building Energy Codes	SBST 302 Building Components & Systems

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