ROOFING ALLIANCE
THE FOUNDATION OF NRCA

PRINCIPLES OF ROOFING FROM DESIGN TO INSTALLATION AND BEYOND

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EXECUTIVE SUMMARY

The U.S. construction industry is currently facing the significant challenge of a declining workforce, even considering issues surrounding the pandemic. Studies of age-related demographics show that the construction industry will not be able to meet its future workforce demands under current conditions. One of the most essential sectors within the construction industry, the roofing industry, faces an even greater challenge than other sectors, presenting a need to build a platform to prepare its next generation of leaders.

With this in mind, faculty at Clemson University's Nieri Family Department of Construction Science and Management, working with the Roofing Alliance – a foundation affiliated with the National Roofing Contractors Association – developed and offered a three-credit course (not previously offered in the curriculum) on roofing at both the undergraduate and graduate level.

This report will show how that course was developed, details of the involvement of roofing industry professionals in its development, the impact of the course on students' learning and their perceptions of the roofing industry.

The first step in developing the course was to measure the industry's perception of the current workforce and the perceived need for a course at the higher education level. It was established early on that a partnership between industry and academia would be key to the success of the project. It was clear from the study of the industry's perception that there was a curriculum gap within construction science, management and engineering programs, and that gap could be filled with a roofing-specific course. During the process of offering the course, the students indicated they felt they had significantly increased their knowledge of roofing, and many expressed an interest in exploring a career in the roofing industry.

STUDY APPROACH / DETAILS

The approach for this study is shown in Figure 1.

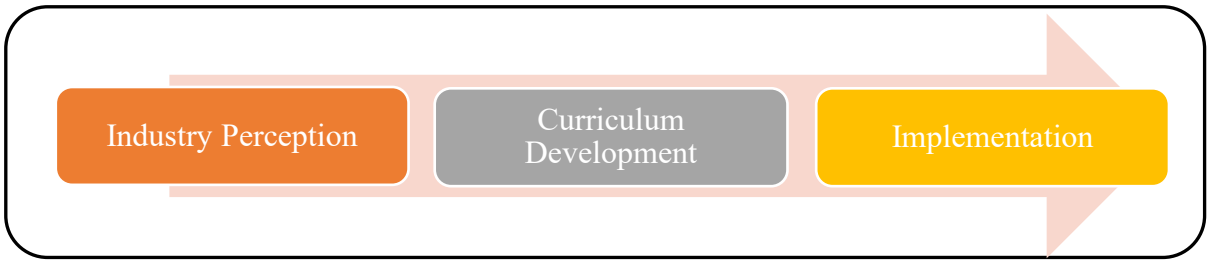

Figure 1. Study Approach

Industry Perception

It was established early on that the industry-academia partnership would be a key factor for the success of this study. This phase included the development and distribution of the initial survey to assess the roofing industry professionals' perception of developing a new roofing course at the higher education level. As part of this phase, a task force of nine industry professional members was created to provide industry expertise, offer feedback and offer key suggestions on developing the curriculum and implementing the course. Each of the industry's key sectors (contractor, manufacturer, and distributor) was represented on this task force.

The initial industry perception survey was developed jointly by the researchers and the task force. The main components of the industry perception survey were:

1. Professional's background information
2. Professional's view on the current state of roofing workforce
3. Professional's view on offering a roofing-specific course at the higher education level
4. Professional's view on providing employment opportunities in the roofing industry for those that have formal roofing education in an academic setting.

The survey was distributed using Qualtrics to 400 roofing professionals by accessing the membership of the Roofing Alliance and National Roofing Contractors Association (NRCA) as shown in Table 1. Others included roof consultants, insurance carriers, law firms and technology/software providers.

Company Background	#	Percent
Roofing Contractor	124	74%
Roofing Manufacturer	19	11%
Roofing Distributor	6	4%
Others	18	11%
Total	167	100%

Table 1. Company Background

A total of 167 roofing industry professionals (out of 400) responded to the initial industry survey. Table 2 outlines the results of the survey.

Statement	Strongly Disagree		Disagree		Neither		Agree		Strongly Agree	
	#	%	#	%	#	%	#	%	#	%
Lack of roofing workforce is a major challenge today	9	5%	1	1%	4	2%	18	11%	135	81%
University graduates lack the basic knowledge regarding the roofing industry	4	2%	4	2%	9	5%	41	25%	109	65%
Educating university students about the roofing industry can help tackle workforce issues	4	2%	12	7%	19	11%	53	32%	79	52%
University programs should include roofing course as part of the curriculum	3	2%	5	3%	12	7%	43	26%	101	60%

Table 2. Industry Perception

Table 2 shows that 92% of survey respondents either strongly agreed or agreed that the lack of workforce is a major challenge in the roofing industry. The survey results validated the initial findings in the literature that workforce development within the roofing industry was a major challenge. 84% of the industry participants also either strongly agreed or agreed that university graduates lack basic knowledge regarding the roofing industry. 84% of survey respondents strongly agreed or agreed that educating university students about the roofing industry could help tackle workforce issues (attracting next generation of leaders) and 86% of the industry participants strongly agreed or agreed that university programs should include roofing course as part of their curriculum.

Also, 156 out of 167 (93.4%) industry participants responded that they were more likely to provide employment opportunities for students with some type of formal roofing education in an academic setting. Hence, the survey findings, along with the existing literature, suggest a need for a roofing specific course at the higher education level.

Curriculum Development

Because roofing is such a diverse and specialized field with multiple types of roof systems, one of the challenges of developing a curriculum framework was to understand the content and concepts that were necessary to be included as part of this course. Hence, a second survey was developed and distributed to the roofing professionals for their input on topics that should be covered in the roofing course, with a special emphasis on the specific skillsets required of a college graduate before entering the roofing workforce. The involvement of industry partners in developing the curriculum helped in incorporating the concepts that are needed from an industry perspective. The second survey was also developed jointly by the researchers and the task force.

Prior to full distribution of the second survey, a pilot survey was conducted with the task force members to verify the clarity of the questions and the survey responses. Feedback from the pilot study included adding specific topics to be covered in the course; identifying career options in roofing; understanding roof specifications; estimating roof projects; and business management.

The main components of the final curriculum development survey were:

1. The professional's background information, including contact information, the type of company (contractor, manufacturer, distributor) represented and the type of roof system specialization (low-slope, steep-slope or both).
2. Ranking of the top ten (out of twenty) topics that the professional deemed appropriate to be covered in the course. Topics that are relevant to each industry sector are also shown (Contractor – C; Manufacturer – M; Distributor – D).
    a. Types and Installation Details of Roofing Systems (C, M)
    b. Building Envelope Systems (C, M)
    c. Building Function (C, M)
    d. Building Codes in Roofing (C, M)
    e. Installation Details of Roof Components (C, M)

f. Reading Roofing Blueprints and Specifications (C, M, D)
g. Roof Estimating (C, M)
h. Roof Scheduling (C, M, D)
i. Roof Safety (C, M, D)
j. Communication (C, M, D)
k. Site Logistics (C, M, D)
l. Roof Repair and Maintenance (C, M)
m. Finance (C, M, D)
n. Roof Procurement / Sourcing (C, M, D)
o. Managing Roofing Business (C, M, D)
p. Field Crew Management (C)
q. Career Options in Roofing (C, M, D)
r. Manufacturing and Distribution Channels
s. The Roofing Industry and the Environment (C, M)
t. Technology in Roofing (C, M, D)

3. Professional's availability in course assistance
   a. Product donations
   b. Content donations
   c. Guest lectures

The survey was distributed using Qualtrics to 167 participants that responded to the industry perception survey. Figure 2 outlines the combined ranking of the twenty topics from all the entities in the roofing industry.

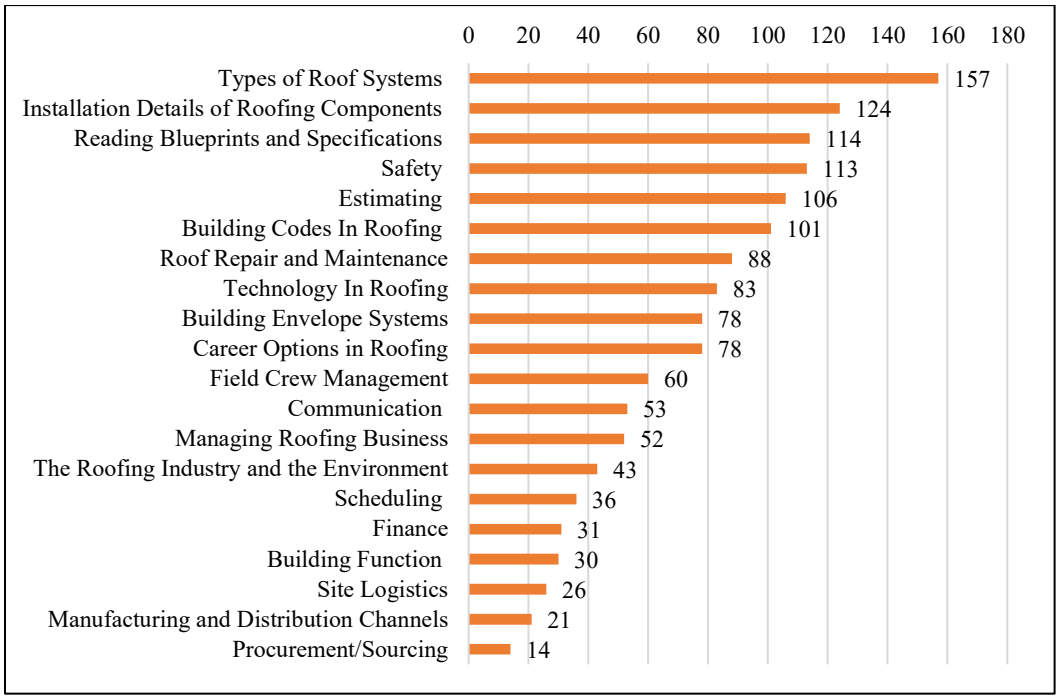

Figure 2. Combined Topic Ranking

However, the combined ranking was heavily favored towards the roofing contractor since the roofing contractor represented 74% of the total survey responses. Further analyses were needed to identify the top ten topics from each major entity, as shown in Table 3, to avoid skewed outcomes toward the roofing contractor survey responses.

Rank	Contractors	Manufacturers	Distributors
1	Types of Roof Systems	Types of Roof Systems	Types of Roof Systems
2	Installation Details of Roofing Components	Building Envelope Systems	Estimating
3	Reading Blueprints and Specifications	Installation Details of Roofing Components	Installation Details of Roofing Components
4	Safety	Reading Blueprints and Specifications	Safety
5	Estimating	Technology in Roofing	Roof Repair and Maintenance
6	Building Codes in Roofing	Safety	Reading Blueprints and Specifications
7	Roof Repair and Maintenance	Career Options in Roofing	Building Codes in Roofing
8	Technology in Roofing	Building Codes in Roofing	Manufacturing and Distribution Channels
9	Field Crew Management	The Roofing Industry & The Environment	Building Envelope Systems
10	Career Options in Roofing	Estimating	Career Options in Roofing

Table 3. Topic Rank by Company Type

The final topics for the roofing course were selected based on the two-factor analysis. The first factor of topic selection was any topic ranked as top ten by all three entities. For example, if the contractor participants ranked "types of roofing systems" in top ten, an "X" was marked on the table. The second factor of topics selection was any topics that were ranked as top ten by a minimum of two entities. Topics that did not meet the two-factor selection criteria were not selected for this course. Table 4 outlines the details of the two-factor analysis.

Topics	Top 10 Topic Selection		
	Contractors	Distributors	Manufacturers
First Factor Selection			
Types of Roof Systems	X	X	X
Installation Details of Roofing Components	X	X	X
Reading Blueprints and Specifications	X	X	X
Roof Safety	X	X	X
Roof Estimating	X	X	X
Career Options in Roofing	X	X	X
Building Codes in Roofing	X	X	X

Topics	Top 10 Topics Selection		
	Contractors	Distributors	Manufacturers
Second Factor Selection			
Roof Repair and Maintenance	X	X	
Technology in Roofing	X		X
The Roofing Industry & The Environment	X		X
Topics Not Selected			
Building Envelope Systems			X
Roofing Procurement / Sourcing		X	
Roofing Manufacturing / Distribution Cannels		X	
Roofing Field Crew Management	X		
Communication			
Managing Roofing Business			
Scheduling			
Financing			
Building Function			
Site Logistics			

Table 4. Top 10 Topics To be included in Course

99 out of 167 (59.2%) industry participants also agreed to assist in developing the course by providing lecture content, product donations, site visits, projects case studies, and online/in-person guest lecture. Table 5 outlines the details of the industry members course participation. Over half of the survey respondents volunteered to participate as in-person guest lectures.

Activity	Total (out of 167)	Percent
In-person Guest Lecture	95	56.8%
Volunteer Site Visits	81	47.9%
Lecture Content	69	41.3%
Project Case Studies	69	41.3%
Virtual Guest Lecture	68	40.7%
Product Donations	48	28.7%

Table 5. Industry Participation

Implementation

Based on the development of curriculum, the roofing course was offered to both undergraduate and graduate students. A total of 21 students (11 undergraduate and 10 graduate) enrolled in this course as shown in Figure 3. Two students (9.5%) were civil engineering majors (one undergraduate and one graduate), while nineteen were construction science and management majors.

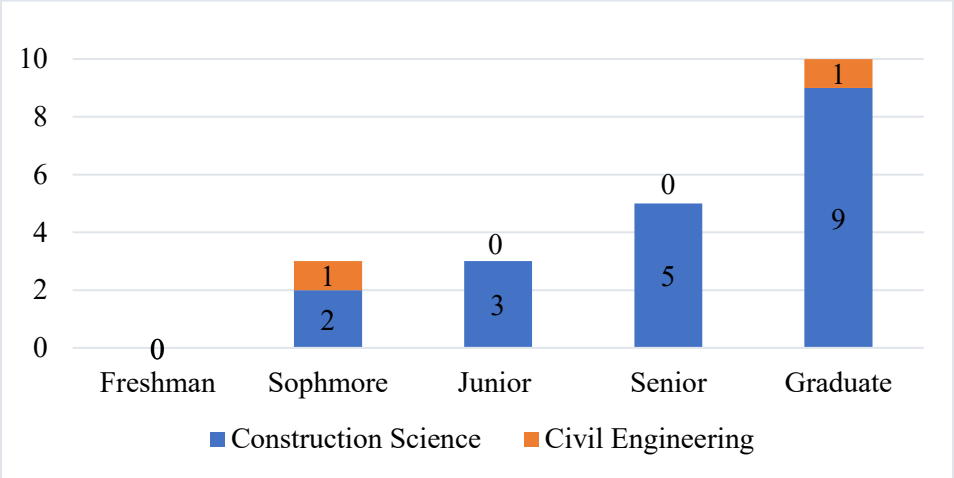

Figure 3. Student Background Information

Based on the input and feedback from the task force members, and due to the involvement of the roofing industry professional's as guest lecturers, the course had the following characteristics:

1. Offered one day of the week for 2.5 hours
2. Class section evenly split between guest lectures and critical thinking in-class assignment.
3. Weekly Quizzes based on the covered concepts
4. Two exams: Mid-term Exam and Final Exam
5. Semester Project
    a. Undergraduate: Roofing Professional Interview and Report
    b. Graduate: Compile Qualifications Package for a Roofing Project

One of the important components of this phase was understanding the impact of this course on student's learning and their perception about the roofing industry. To that end, perception surveys were conducted at the beginning of the semester (pre-survey) and at the end of the semester (post-survey) to both undergraduate and graduation sections to assess their perceptions about the roofing industry.

The main components of the pre and post surveys are outlined in Table 6. A comparative analysis between preferred aspects and the perception questions of the surveys were performed.

Survey Component	Pre-Survey	Post-Survey	Comparative Analysis
Student Background	X	X	
Preferred Aspects	X	X	X
Overall Learning		X	
Overall Satisfaction		X	
Perception Questions	X	X	X

Table 6. Perception Survey

Pre-Survey

The beginning of the semester survey (i.e. pre-survey) was created to understand the students' background and current knowledge about the roofing industry, students' interest in enrolling in the course, and perception about the roofing industry prior to the course offering. The pre- survey was distributed during the second week of the course offering. Table 7 shows the student background details, either with prior work experience or a previous formal roofing course.

Question	Yes		No	
	#	%	#	%
Do you have any prior experience working in the roofing industry?	0	0%	21	100%
Have you ever enrolled in a roofing specific course prior to this course?	2	10%	19	90%
Do you have a family member that works or owns a roofing related business?	0	0%	21	100%

Table 7. Student Background Questions

Table 7 shows that enrolled students had no prior experience working in the roofing industry. Only two out of the nineteen students had enrolled in a formal roofing specific course. The two students' who have had some experience in a prior roofing course were part of a national roofing competition team prior to implementing this course.

One of the aspects of the pre- survey was to understand the student's preferred aspects in enrolling in this course as shown in Table 8. Students were asked to rate each statement on a scale of 1 to 10 with one being least important and ten being most important along with an open-ended question for any other reason.

Rank	Reason	Average (out of 10)	Standard Deviation
1	Learn more about the roofing industry	8.62	1.46
2	Various topics covered in this course	8.57	1.80
3	Industry members participation	7.81	2.52
4	Recommended by a faculty member/advisor	6.14	3.75
5	Learn about different career options in the roofing industry	6.00	3.23
6	Class day/time	4.86	3.07
7	Recommended by a fellow student	2.86	3.00

Table 8. Student Preferred Aspects

Table 8 shows that the curiosity to learn more about the roofing industry, various topics covered in the course, and industry members' participation were the top three reasons for student enrollment in this course. Typically, student enrollment in a specific course heavily replies upon the recommendation by a faculty member and advisor which was ranked fourth. Table 8 also shows

that the industry member's involvement in both curriculum development and course implementation was a critical factor for student enrollment.

The pre- survey also focused on collecting and analyzing the perception of the enrolled students about the roofing industry at the beginning of the course, as shown in Figure 4.

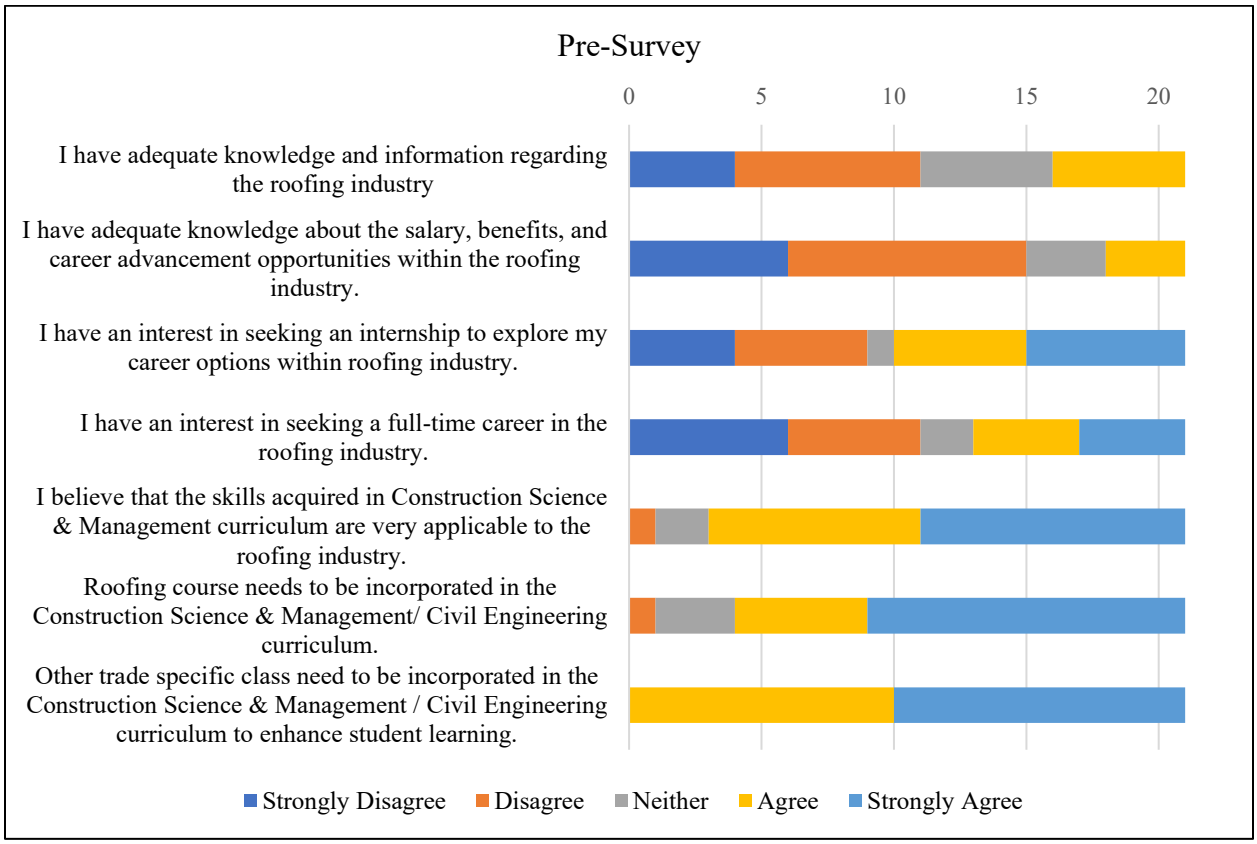

Figure 4. Pre-Survey Student Perception

Figure 4 shows that only five students (23.8%) enrolled in the course agreed that they have adequate knowledge and information regarding the roofing industry. Moreover, only three students (14.2%) enrolled agreed that they have adequate knowledge about the salary, benefits, and career advancement opportunities within the roofing industry indicating there is a lack of knowledge among students about the roofing industry. This showed that there was a lack of knowledge among students about the roofing industry. Since the survey was distributed in the second week and the topic for the first week being roofing introduction and different career options in the roofing industry, eight students (38.1%) strongly agreed or agreed that they have an interest in seeking a career in the roofing industry.

Seventeen students (80.9%) strongly agreed or agreed that the roofing course should to be incorporated within the Construction Science and Management / Engineering curriculum. All twenty-one students (100%) also strongly agreed or agreed that other trade-specific courses also need to be incorporated within the curriculum.

Post-Survey

The end of the semester survey (post-survey) was created to understand the students' preferred aspects of the course, the course's impact on student learning about the roofing industry, the perception of the roofing industry, overall course satisfaction and interest in developing additional courses. Table 9 shows how the students rated preferred aspects of the course, with10 being most preferred aspect. The survey also included an open-ended question for other preferred aspects.

Rank	Criteria	Average (Out of 10)	Standard Deviation
1	Industry professional's delivering guest lectures	9.33	0.96
2	Various topics covered in this course	8.90	1.45
3	Layout/structure of the individual class (lecture + in-class assignment)	8.62	1.39
4	Semester Project	8.38	2.01
5	Weekly Assignments	7.57	2.96
6	Class Day / Time	7.52	2.71

Table 9 Students Preferred Aspects

Table 9 shows that the industry professional's involvement in delivering guest lectures, the variety of topics covered in the course and the layout and the structure of the individual class were the top three preferred aspects. The layout/structure of the individual class was an even split between guest lecture and critical thinking group assignment.

Table 10 shows the students' perspective on the topics that they perceived they had learned the most. Students were asked to rate each statement on a scale of 1 to 10 with 1 being least learned and 10 being most learned.

Rank	Topic	Average (Out of 10)	Standard Deviation
1	Low Slope Roofing System – BUR, Modified Bitumen	8.71	1.85
2	Low Slope Roofing System – TPO, EPDM, PVC	8.71	2.23
3	Low Slope Roofing System – Fluid Applied Roofing Systems, Green Roofs, Solar Roofs	8.67	1.53
4	Steep Slope Roofing System – Slate/Metal Panels	8.29	1.93
5	Roofing Estimating	8.24	2.23
6	Safety in the Roofing Industry	8.30	2.32
7	Roof Repair & Maintenance	8.05	2.01
8	Reading Roofing Blueprints	7.86	2.74
9	Reading Roofing Specifications	7.86	2.90
10	Steep Slope Roofing System – Asphalt Shingles	7.71	2.57
11	Technology in Roofing	7.83	2.55

Table 10 Student Learning

Table 10 shows that the top three topics that students learned about were low slope roofing systems, which can be categorized as "different types of roofing systems." The three topics that the students learned the least from are reading roofing specifications, steep slope roofing system – asphalt shingles, and technology in roofing. However, it was identified that the percent difference between the first ranked topic and the tenth-ranked topic was only 12%.

The post-survey also focused on collecting and analyzing the perception of the enrolled students about the roofing industry at the end of the course offering as shown in Figure 5.

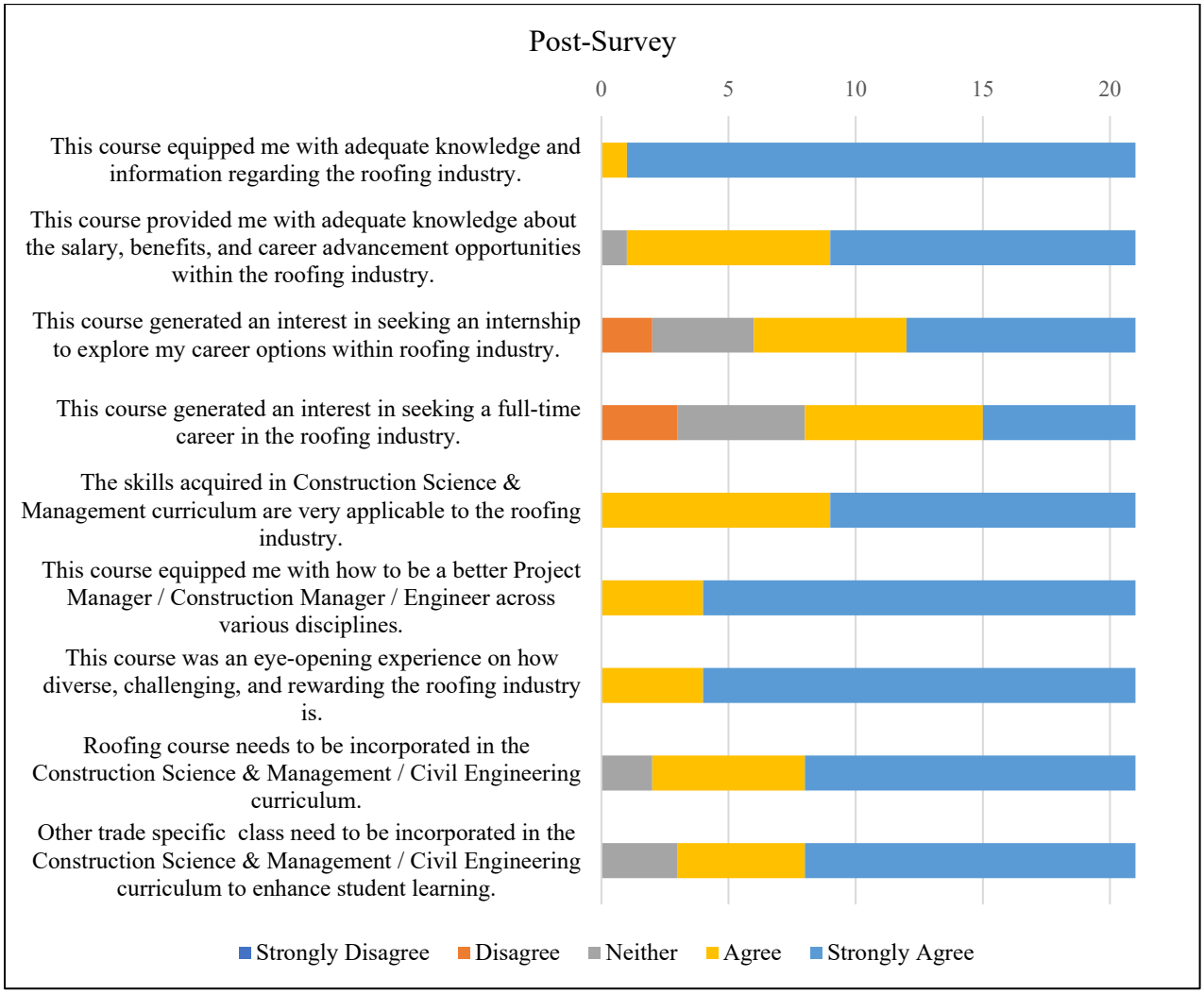

Figure 5. Post-Survey Student Perception

Figure 5 shows that all twenty-one students (100%) enrolled in the course strongly agreed or agreed that the course had equipped them with adequate knowledge and information regarding the roofing industry. Moreover, twenty students (95.2%) strongly agreed or agreed that this course equipped them with adequate knowledge about the salary, benefits, and career advancement opportunities within the roofing industry. At the end of the course, fifteen students (71.4%)

strongly agreed or agreed that they have an interest in seeking an internship to explore their career options in the roofing industry. All twenty-one students (100%) also strongly agreed or agreed that this course prepared them to be a better Project Manager / Construction Manager / Engineer across various disciplines. 100% of the students also strongly agreed or agreed that this course was an eye-opening experience on how diverse, challenging, and rewarding the roofing industry is.

Comparative Analysis

In order to understand the impact of the roofing course, a comparative analysis of the perception questions between the pre-survey and post survey were performed as shown in Figure 6.

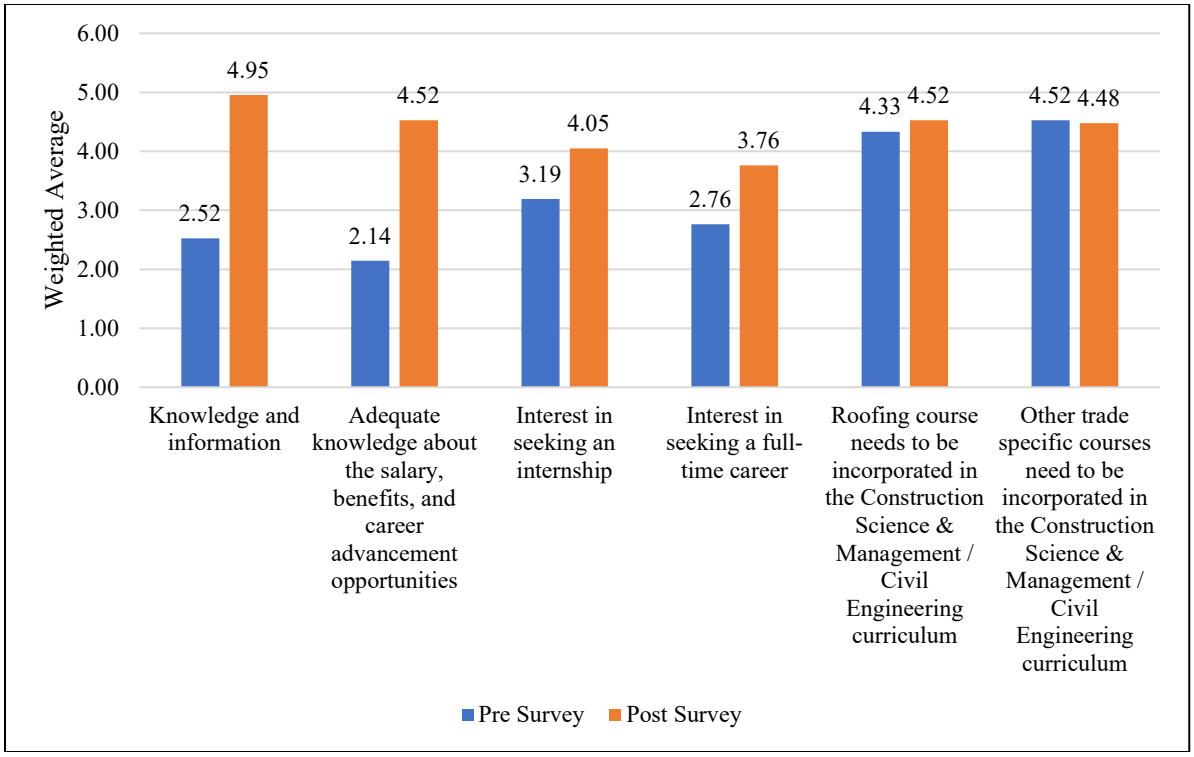

Figure 6. Comparative Analysis

Figure 6 shows a significant increase with a percent difference of 65% in reporting that they have adequate knowledge and information regarding the roofing industry. There was a percent difference of 71.5% in students' understanding of salary, benefits, and career advancement in the roofing industry. Interest in seeking an internship and interest in seeking a full-time career in the roofing industry also showed a percent difference of 23.8% and 30.7% respectively.

The students were also asked to provide an overall satisfaction with this course on a scale of 1 – 10, with one being not satisfied at all and ten being very satisfied. The overall satisfaction for the course was 9.1 out of 10. 75% of the students rated the course at 9 or higher and 95% of the students rated it at 8 or higher. Moreover, 75% of the students expressed an interest in the development of a certificate program in roofing that would offer two additional courses.

KEY TAKEAWAYS

The study aimed to understand industry's perception of the current workforce, industry's perception of offering a roofing specific course at the higher education level and its willingness to help develop a three-credit course in an attempt to improve students' knowledge about the industry and their perception of it.

Based on the initial industry perception survey, it was concluded that the survey's findings aligned with the existing literature. The current workforce shortage, combined with the need to develop a workforce for the future, is seen as a major challenge facing the roofing industry. From this study, 92 percent of respondents agree that the lack of a qualified workforce is a significant challenge in the roofing industry today.

In order to address this challenge, educating higher education students becomes critical. From this study, 84 percent of survey respondents agree that educating university students about the roofing industry can help tackle workforce issues. Hence, it was concluded that there is a need for a roofing-specific course at the higher education level, especially since trade-level subcontractors have started to recruit their future workforce from higher education institutions.

The curriculum for the roofing course was developed by utilizing the industry members' expertise through an industry-wide survey. A task force, comprising of roofing contractors, roofing material manufacturers and roofing wholesale distributors was able to provide ongoing continuous feedback throughout the study. Surveys and studies were able to capture the needs of the roofing industry and the key concepts that the industry deemed important to incorporate into the course curriculum. Moreover, one of the top three reasons for the students' enrollment in the course, identified in both pre- and post-course surveys, was the "various topics" covered in the course. That was made possible by the active involvement of industry experts in curriculum development and through guest lectures.

The classes were evenly divided between guest lectures from industry professionals and critical thinking group assignments. Students ranked the "involvement of industry professionals" in the course as one of the top three reasons they chose to enroll and one of the top three attributes of the course. It was therefore concluded that active involvement of roofing industry professionals in both curriculum development and implementation was a critical success factor.

Comparing the pre- and post-course perception surveys, a difference of 65 percent suggests that the course was successful in providing the students with adequate knowledge about employment opportunities in the roofing industry – one of the key objectives identified by industry professionals. Interest in seeking an internship in the roofing industry and interest in seeking full-time career options in the roofing industry increased by 23.8 percent and 30.7 percent, respectively. The students also reported an overall satisfaction of 9.1 out of 10 for the course.

Offering a roofing-specific course not only helped to fill the current curriculum gap, but also provided the students with adequate information about the roofing industry and generates an

interest to explore roofing as a possible career path. The framework that was chosen – using industry perception surveys, creating a task force of industry experts and involving industry in the course development and layout – is one that can be easily replicated by other construction management programs.

Out of the twenty topics identified by the study, only ten were covered in this course. Future additional courses, as part of a certificate program, will be developed to include additional topics identified by this project – and others that will evolve over time.

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- Thomas Roofing
- JD Miles & Sons
- Miles Roofing, Inc.
- Nations Roof
- Peterson Aluminum
- King of Texas
- Siplast
- Piper Roofing
- Cornell Roofing
- Klein Contracting
- Karnak
- Peter Roofing
- Eagleview
- Evans Roofing Company
- Sutter Roofing
- Firestone
- GAF
- CertainTeed
- Carlisle
- Tremco
- Tamko
- Beacon Roofing Supply
- Soprema
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- John Geary
- David Martiny
- Brady Campbell
- Roddy Piper
- Robert Pringle

APPENDIX A – COURSE SCHEDULE

Date	Subject
Week #1	Course Introduction; Introduction to Roofing; Career Options in Roofing - Course expectations - Course grading policies - Introduction to different types of roofing systems, different entities and their roles in the roofing industry - Different career options in the roofing industry
Week #2	Steep Slope Roofing Systems - Asphalt Shingles, Concrete / Clay Tiles, Wood Shakes - Different product details - Installation details for different membranes - Roofing components
Week #3	Steep Slope Roofing Systems – Slate, Metal Panels - Different product details - Installation details for different membranes - Roofing components
Week #4	Low Slope Roofing Systems – Built-up Roofing, Modified Bitumen - Different product details - Installation details for different membranes - Roofing components
Week #5	Low Slope Roofing Systems – Single-ply Thermoset and Thermoplastic - Different product details - Installation details for different membranes - Roofing components
Week #6	Low Slope Roofing Systems – Fluid Applied Roofing Systems, Photovoltaic Roof, Vegetative / Green Roof - Different product details - Installation details for different membranes - Roofing components
Week #7	Reading Blueprints - Understand how to navigate blueprints specific to the roofing scope - Understand and interpret the overall roofing drawings - Understand details and sections on the drawings for connections, flashing, penetrations, parapet wall, etc. - General contracting vs. roofing blueprints

Date	Subject
Week #8	Reading Specifications - Understand how to navigate roofing specifications - What is included in the roofing specifications? - How to find the relevant information on the roofing specifications?
Week #9	*Mid-term Examination*
Week #10	Roofing Estimating I - Basic aspects of roofing estimating i.e. what to include in the roofing estimate - Different product pricing - Quantity take-offs from blueprints (membrane, insulation, drains, gutters, downspouts, fasteners, etc.)
Week #11	Roofing Estimating II - Labor & crew cost estimating - Equipment and mobilization estimating - General conditions
Week #12	Safety in the Roofing Industry - Safety plan overview - Key aspects of roofing safety (material handling, ladder safety, equipment safety, fall protection systems, etc.)
Week #13	Roof Repair & Maintenance - Conducting visual inspections - Key techniques in finding leaks and defects in the roofing system - Proactive roof maintenance techniques
Week #14	Technology in Roofing - Technological innovations in roofing (drones, software, innovative roofing materials, smart equipment, etc.)
Week #15	Final Exam