

## **Cross Sectional Assessment of CEM Curriculum Offerings at the Pre-college level in North Carolina (Evaluation)**

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# **A Cross-Sectional Assessment of CEM Curriculum Offerings at the Pre-college Levels in North Carolina**

## **Abstract**

Career and Technical Education (CATE or CTE) is essential at the pre-college level since students primarily make career decisions during this time. CTE curriculum is implemented in various schools, including Title 1, to develop knowledge for students regarding technical careers. The construction, engineering, and management (CEM) curriculum is a type of CTE curriculum designed to educate pre-college level students about careers in the construction industry. Knowledge opportunities about the construction industry can contribute to a workforce shortage. Research suggests a shortage of future workforce in the construction industry within the next decade or by 2040. Assessing the CEM curriculum at the pre-college level is needed to understand how the current state of CEM education impacts current workforce trends. Based on the literature review, the researcher developed a study to understand the current state of the CEM curriculum at the middle and high school levels by assessing course offerings in North Carolina for the 2019 – 2020 academic year. The researcher hopes to learn the course names, course topics, and the CEM curriculum within a school. For this study, the data gathered will reflect the top five populated counties in North Carolina, representing 33% of the overall population.

## **Introduction**

The size of the available workforce in the construction industry decreases for both management and skilled professionals [1]. According to the National Center for Construction Education and Research (NCCER), 40% of today's construction workforce will retire by 2030 [2]. Unfortunately, there is not enough young workforce entering the construction industry between the ages of 16-24 to offset the number of experienced professionals retiring [3]. Research also suggests that a contributing factor to this decline in the construction workforce is the low level of attraction among the younger generation [4]. A poll of young adults (ages 18-25) found that only 3% considered a career in the construction industry as a desirable career path [5]. This low level of attraction amongst the youth impacts the construction industry's current state [6]. As a result, there is a need to educate and attract the available young workforce into the construction industry [7].

Research also suggests that previous methods used to attract the older workforce will likely be different from those used to attract the young workforce into the industry today [8]. Career education is one way to attract the young workforce into any essential industry [9]. There is also a high demand for students as future professionals with formal education in the CEM curriculum [10]. For this study, the young workforce is pre-college (middle and high school) level, students. Studies show that career education at the pre-college level is critical since students are at a critical age. Exposure to industries such as construction can impact their career goals [11]. However, before implementing career education courses at the pre-college level, it is essential to assess the current state of course offerings within the CEM curriculum. This study evaluates the current state of CEM course offerings in the top five populated counties in North Carolina at the pre-college level. This study specifically addresses the following research questions:

1. What are the CEM courses offered at the pre-college (middle schools and high schools) level during the 2019 – 2020 academic year in North Carolina?
2. What topics are included within CEM courses at the pre-college (middle schools and high schools) level during the 2019-2020 academic year in North Carolina?
3. Is there a difference in CEM course offerings at the pre-college (middle school and high school) level during the 2019-2020 academic year in North Carolina between Title 1 and non-Title 1 schools?

A Title 1 school is when over 40% of the student population qualifies for free or reduced lunch and intends to narrow the achievement gap between itself and other schools [12].

## **Literature Review**

### CEM Curriculum

CEM curriculum exists due to the nature of the construction industry's complex environment. CEM education's design is to prepare students to work in the continually evolving and high expectations construction industry [13]. CEM is a STEM program under the umbrella of construction education, where the curriculum uses the categories of construction technology, construction techniques, construction engineering, and construction management [14]. Education programs designed for CEM focus on the applications, technology, and practical skills required to succeed in the construction industry. Additionally, key CEM concepts are clusters that appeal to construction professionals, including managerial, planning, and engineering skills [15]. The key CEM concepts identified for this study are listed below:

- Cost / Estimating [16]
  - Estimating is construction math focused on the costs associated with the project. Assignments in the course involve math using a ruler or scale to determine costs. Additional assignments can include quantity takeoffs and cost estimates.
- Equipment / Power Tools [17]
  - Equipment is managing the construction process with some exposure to technology, such as hand tools or power tools.
- Safety [18]
  - Risk mitigation associated with job site management of safety methods and techniques. The course may offer OSHA 10 certification to fulfill the safety objectives.
- BIM (Building Information and Modeling) [18]
  - BIM is any information technology required for building design. The course may offer topics, including Computer Aided Designs (CAD).
- Project Management [16]

- Project Management is the basics of construction planning and construction control methods.
- Scheduling [16]
  - Scheduling is a course that includes the basics of construction scheduling and information technology associated with project phasing.
- Materials & Methods [17]
  - Materials and methods include design properties, construction properties, and the standards associated with construction materials.
- Contract Documents [18]
  - Contracting is different contract delivery methods and learning how to read construction blueprints.

### Precollege Level

Previous studies found the peak level of when students are interested in making career choices. Studies found that if a middle school student indicated an interest in a STEM field, 66% of them are more likely to achieve a STEM field degree during their college education [19]. Students make choices during middle school years, such as what courses to enroll in, impacting future career aspirations [20]. Also, middle school students make choices that can affect future career and education opportunities [21], emphasizing the need to understand the middle school curriculum. There is also societal pressure to make preliminary career decisions before high school [22]. A survey of Oklahoma parents concluded that 54% agree schools should begin career education options in middle school compared to 28% in high school and 18% in elementary school [23].

Additionally, the study found that 40% of students began discussions in middle school about careers or jobs after high school [23]. During their middle school years, students explore various career-making decisions towards a wide variety of industries. Therefore, middle school students are a potential future workforce for the construction industry.

Most students enter high school with a general plan of study from middle school, enabling them to prepare for the next steps towards their career choice. Consequently, efforts are needed to educate students about the construction industry at the high school level since it is at this time students set up goals that align with career interests [11]. Moreover, there is a need to understand any identified gaps in knowledge of careers in the construction industry [24]. High school students are a potential future workforce because research shows that students decide on a career choice currently [25]. High school students' CTE course choices can impact the unemployment and underemployment rate of the future workforce. [20].

### North Carolina

Companies in North Carolina report having difficulty filling some or all positions, including salaried and skilled professionals. This identified shortage indicates a need for various methods

to attract and sustain the workforce. In 2019, North Carolina contributed \$21.6 billion of construction volume to the services produced in the country [26]. North Carolina equated to 3% of the national GDP (Gross Domestic Product) for 2019. However, North Carolina is experiencing decreasing employment rates compared to the year 2018 [26]. In North Carolina, 75% of the construction industry companies reported having difficulty filling some or all positions, including salaried and skilled professionals [23]. This identified shortage indicates a need for various methods to attract and sustain the workforce. As per [27], the demand for construction workers varies by region in the United States, and the West and South regions face the most significant shortage of workers. The top five populated counties in North Carolina are selected for the study because the counties represent 33% of the state’s population of students [28]. The top five populated counties were selected because these counties account for most (32.1%) of the state’s net population [29].

## Methodology

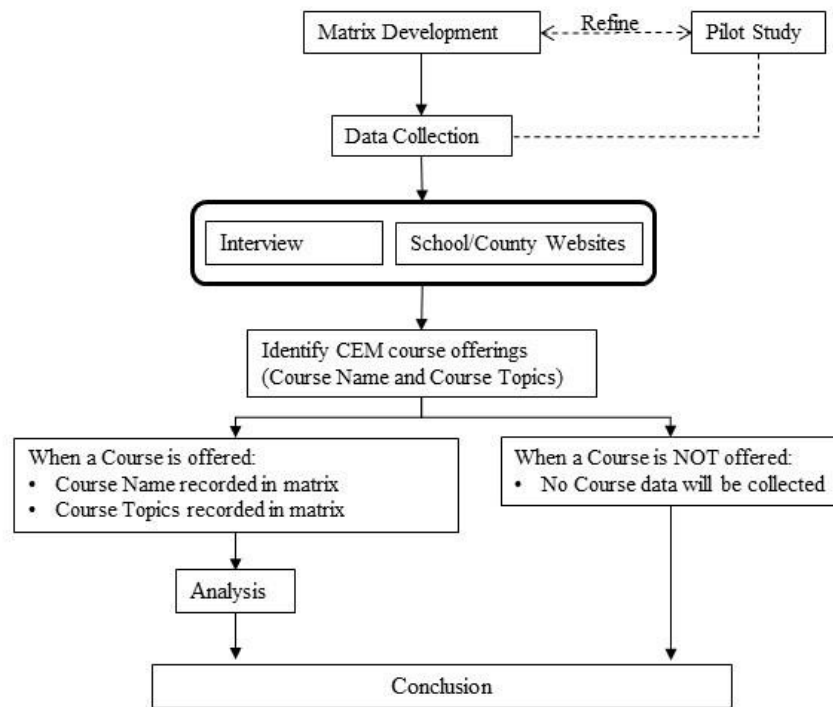


Figure 1 Methodology Matrix

### Pilot Study

There was a pilot study using County #2 school system high schools before the study commences. The school county website has a list of the high schools and the school background information. A list of all the courses and the course description for each school was available on the school county website. However, for the schools that offered a course within the CEM curriculum, only the course name was available on the school county website. Additional

information such as critical topics included within the course is not available on the school county website.

The pilot study concluded that a method to gather additional data, such as topics included within the CEM course, a survey interview to interview teachers and counselors of CEM education, will be needed.

Based on the pilot study, here are the following modifications added to the methodology.

- Add Sustainability topic to the matrix [30]
  - Sustainability is an emphasis on environmental issues, LEED certification requirements, and recycling of construction materials.
- Add CEM course teacher contact information to the matrix.
- Develop a survey interview.

### Data Collection

Data was collected using the information found on school county websites and survey interviews. The researcher identified school background information and any courses offered within CEM (course name) on the school county websites. The information found on the school county websites is in the data matrix. After collecting background data on school county websites, the researcher interviewed to gather data for key topics included within the course. During the interview, the researcher asked for the topics included in the courses. Only the course name and the course topics are in the matrix. Table 1 shows the Interview Respondents Background Data. The questions asked during the survey interview are in Appendix A.

<u>Survey Interview Background Data</u>	
Number of Middle School Teachers	3
Number of High School Teachers	22
Total Number of Respondents	25

Table 1 Interview Respondents Background Data

The study sample is CTE teachers and school counselors from each middle and high school in the top five populated counties. A cold call method to contact survey participants to participate in the study. The response rate is 10% for the North Carolina pre-college level study participants.

### Matrix Development

The critical topics within CEM from the literature review are used to develop a matrix to record course names and course topics within each course. The course topics and school background information were used as headers for the matrix listed below.

#### School Background Information

- School Name
- School Location
- Type of School

- School Number
- School Population

#### CEM Course Topics [17]

- Cost / Estimating
- Equipment / Power Tools
- Safety
- BIM
- Project Management
- Scheduling
- Materials & Methods
- Contract Documents

#### Analysis

The analysis for the matrix is performed in two steps. Upon reviewing the school county websites, course planning tools (syllabus), and survey interview responses, the study is analyzed using descriptive quantitative and qualitative analysis. For this study, thematic coding and a count data model will be used.

The first analysis will include thematic coding for descriptive qualitative analysis for the critical course topics using the course planning tool (syllabus). Each key topic within the course planning tool (syllabus) is coded that matches the literature definitions and recorded in the matrix.

Based on the first analysis, the second analysis will include a count data model for quantitative analysis to evaluate the number of schools that offer CEM courses. The formula for the count data model is:

$n$  = the number of occurrences of CEM course topic

$\sum xi$  = the total number of schools

$\bar{x}$  = the percentage

$$\frac{n}{\sum xi} = \bar{x}$$

#### **Findings**

#### Background

Utilizing school county websites, the researcher began data collection. The information recorded was contact information for the survey interview, school population, and Title 1 status. Table 2 shows a breakdown of the background information collected from school county websites.

<b>North Carolina Schools Breakdown</b>
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	County #1	County #2	County #3	County #4	County #5	NC Overall State
<b>Number of Middle Schools</b>	38	43	22	16	19	138
<b>Number of High Schools</b>	31	31	28	17	17	124
<b>Total Number of Schools</b>	69	74	50	33	36	262
<b>Number of Title 1 Schools</b>	12	19	19	14	14	78
<b>Percentage of Title 1 Schools</b>	17%	26%	38%	42%	39%	30%
<b>Number of Students</b>	85,503	79,445	39,241	32,763	26,763	263,712

Table 2 North Carolina School Background Data

For this research, County #1 is the most student-populated county in North Carolina. County #5 is the fifth most student-populated county in North Carolina; as the counties decrease in student population, the percentage of Title 1 schools increases. Overall, for the state of North Carolina, the Title 1 percentage is 30% of schools. Table 3 shows the number of Title 1 schools in North Carolina.

<b>Number of Title 1 Schools</b>					
	County #1	County #2	County #3	County #4	County #5
<b>Middle Schools</b>	8	16	14	9	11
<b>High Schools</b>	4	3	5	5	3
<b>Overall</b>	12	19	19	14	14

Table 3 Number of Title 1 Schools

Title 1 schools serve a high percentage of low-income students. Understanding the curriculum available to Title 1 students can be used to make the curriculum more equitable for all students [31]. North Carolina has identified workforce needs that may be filled by qualified future workforce (Title 1 students) depending upon early access to the CEM curriculum.

North Carolina Overall

Between the academic years of 2019 – 2020, the course offering of the CEM curriculum was present throughout the NC school system in the top five populated counties. Figure 1 shows the number of schools that offer the CEM curriculum. In North Carolina, only 14% of middle schools and 25% of high schools offer a course in the CEM curriculum. At the middle school level, only three counties offer the CEM curriculum. However, at the high school level, all five counties offer a CEM curriculum.



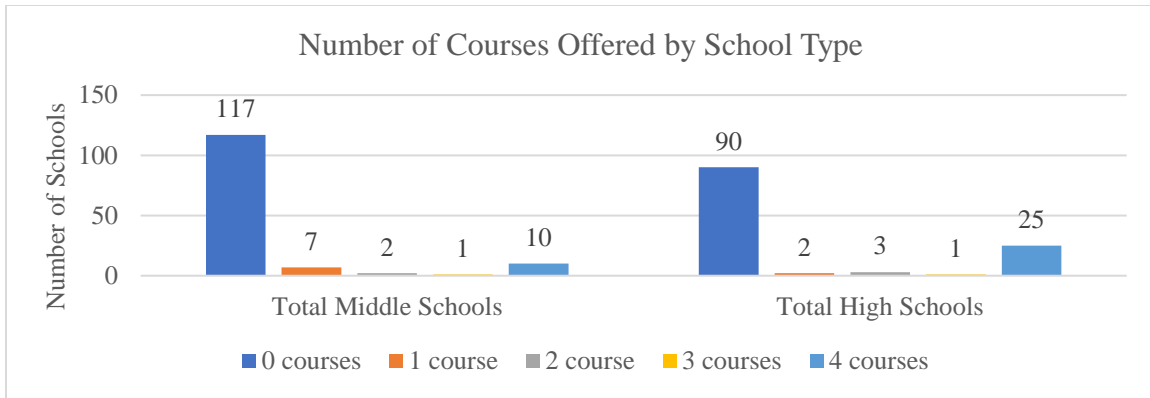


Figure 2 Number of Courses Offered by School Type

Sustainability (12%) and Cost/Estimating (11%) are the most popular topics included in the CEM curriculum at the middle school level. Contract Documents, Safety, and Materials & Methods are the most popular topics included in the CEM curriculum at the high school level. Figure 2 shows the topics offered by school type (middle school or high school).

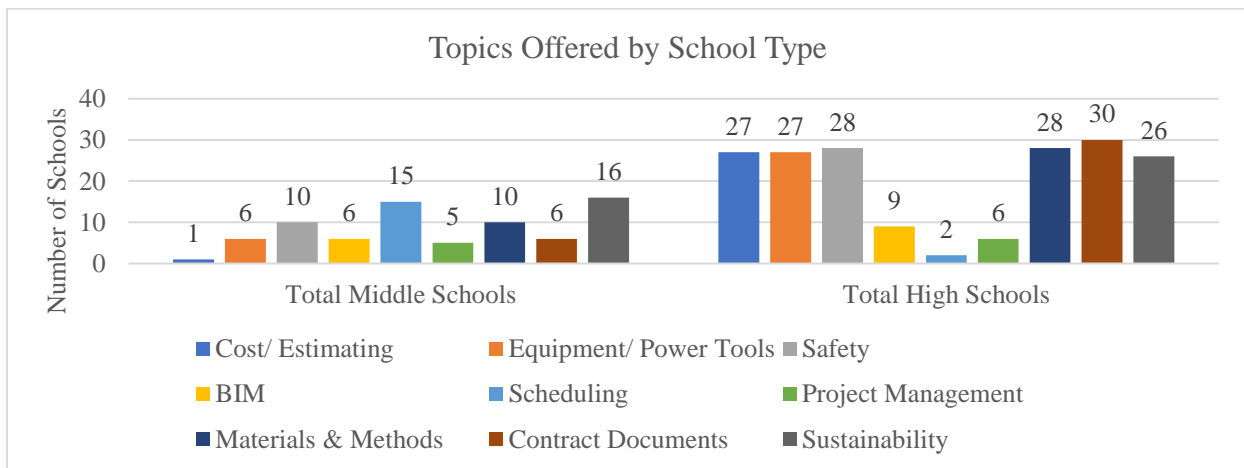


Figure 3 Topics Offered by School Type

Overall, most schools (85% of middle schools;73% of high schools) do not offer a CEM curriculum. There are a low number of schools at the middle school level that offers courses with topics in Cost/Estimating and Project Management. There are a low number of schools at the high school level that offers courses with topics in Scheduling, Project Management, and BIM.

### Middle School

At the middle school level, 14% of schools offer a CEM curriculum. In Research Question (RQ) 1, the objective is to identify the specific courses at the pre-college level in which the CEM curriculum is included. The researcher compiled this list of course names utilizing data gathered from school county websites or survey interviews. Table 4 shows the number of schools offering specific courses with CEM topics at the middle school level.

Middle School Names of Courses	
Name of Course	Number of Schools Offering
<b>Technology, Engineering, &amp; Design</b>	18
<b>Engineering &amp; Design</b>	13
<b>Innovation &amp; Invention</b>	10
<b>Design &amp; Creativity</b>	10
<b>STEM Class</b>	5
<b>Design &amp; Modeling</b>	5
<b>Technological Systems</b>	2
<b>STEM Lab</b>	1
<b>STEAM Class</b>	1
<b>Exploring Engineering &amp; Design</b>	1
<b>Environmental Sustainability</b>	1
<b>Energy &amp; The Environment</b>	1

Table 4 Middle School Name of Courses

At the middle school level, the course named “Technology Engineering & Design” is offered the most (13%). In RQ2, the research objective is to identify the topics included within CEM courses at the pre-college level. Figure 3 shows the CEM Topics by County for the middle school level.

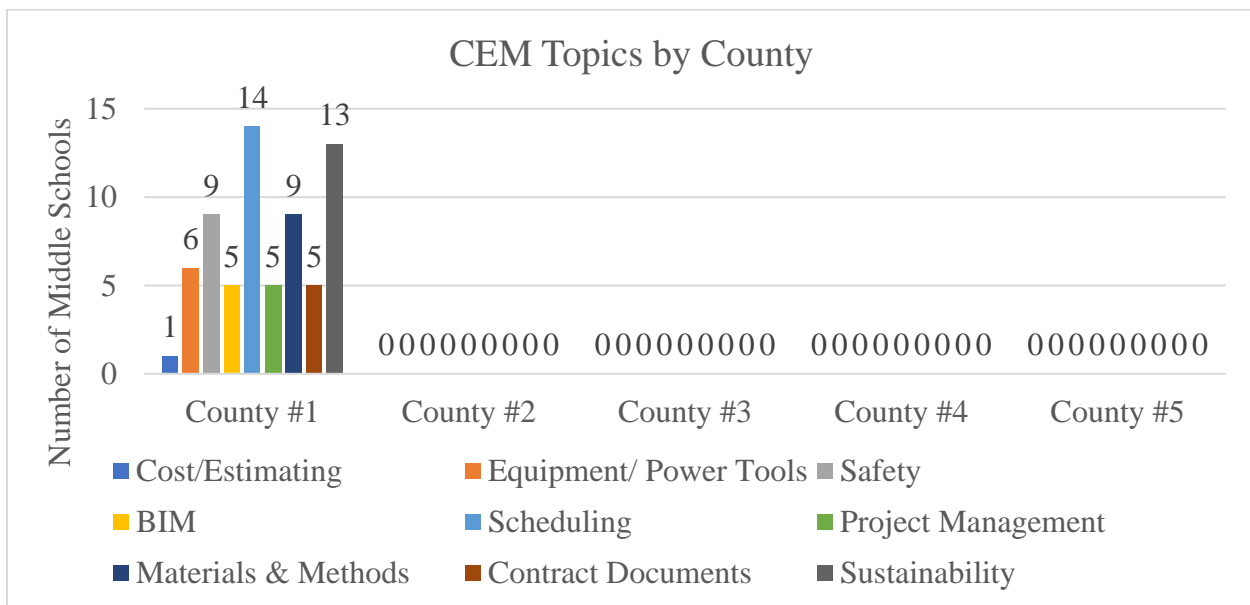


Figure 4 CEM Topics by County

County #1, the county with the least amount of percentage of Title 1 schools at the middle school, has the most schools that offer a CEM curriculum. Scheduling is a popular topic (37%). In RQ3, the research objective is to identify variations between Title 1 and non-Title 1 schools. The data in Figure 3 does not include Title 1 schools.

There are no Title 1 schools at the middle school level that offer a CEM curriculum with topics in cost/estimating, equipment/power tools, and project management. County #1, County #2, and County #5 each have one Title 1 school that offers a CEM curriculum.

High School

At the high school level, 25% of high schools offer at least one CEM course. In RQ 1, the research objective is to identify courses offered at the pre-college level. Table 5 shows the names of courses offered at the high school level in North Carolina.

<b>High School Names of Courses</b>	
<u>Name of Course</u>	<u>Number of Schools Offering</u>
<b>Core</b>	21
<b>Carpentry</b>	20
<b>Drafting</b>	4
<b>Civil Engineering &amp; Architecture</b>	3
<b>Electrical</b>	2
<b>Building Skills</b>	1
<b>Drone</b>	1
<b>Engineering Drafting</b>	1
<b>Generating Clean Electrons</b>	1
<b>Masonry</b>	1
<b>Working Towards Sustainability</b>	1

Table 5 High School Name of Courses

A course named Core is the most popular (17%) course offered. In RQ2, the research objective is to identify the topics included within CEM courses at the pre-college level. Figure 4 shows the

CEM topics by county for high schools in North Carolina. Figure 4 does not include Title 1 schools.

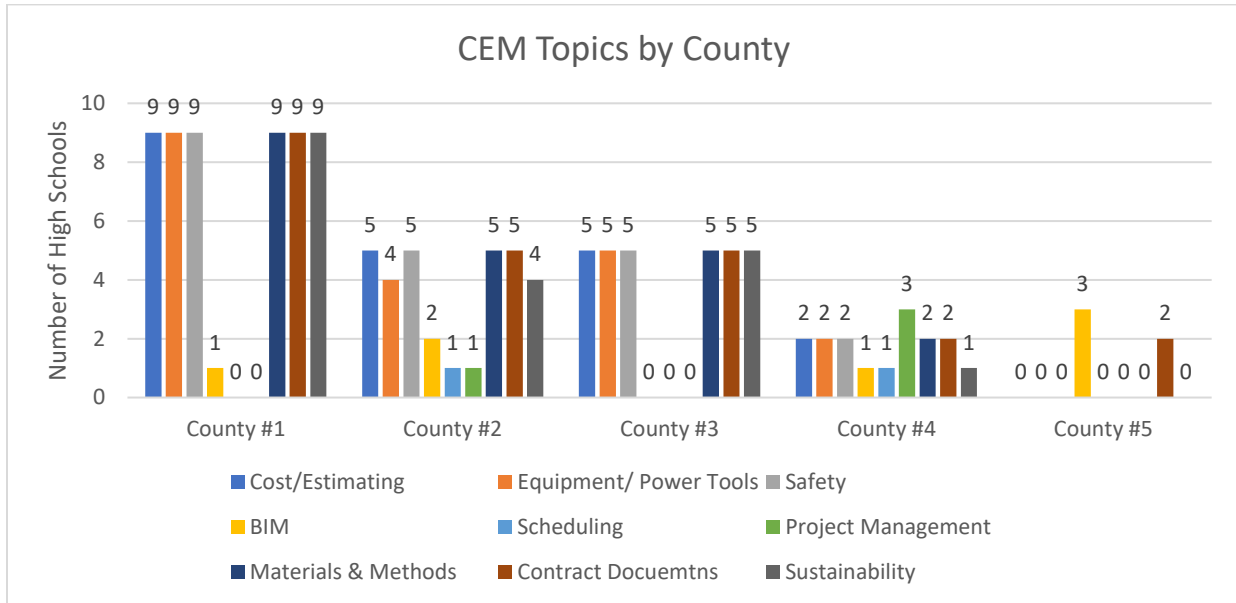


Figure 5 CEM Topics by County

County #1, the county with the lowest percentage of Title 1 schools, has the most (29%) schools that offer CEM curriculum. Cost/Estimating, Equipment/Power Tools, Safety, Materials & Methods, Contract Documents, and Sustainability are the most popular topics offered at the high school level. In RQ 3, the research objective is to identify a variation between non-Title 1 and Title 1 schools.

Topics	Number of Title 1 Schools									
	County #1		County #2		County #3		County #4		County #5	
	MS	HS	MS	HS	MS	HS	MS	HS	MS	HS
Cost/Estimating	0	2	0	1	0	1	0	1	0	1
Equipment/ Power Tools	0	2	0	1	0	1	0	1	0	2
Safety	1	2	0	1	0	1	0	1	0	2
BIM	1	0	0	0	0	0	0	0	0	2
Scheduling	1	0	0	0	0	0	0	0	0	0
Project Management	0	0	0	0	0	0	0	0	0	2
Materials & Methods	1	2	0	1	0	1	0	1	0	2
Contract Documents	1	2	0	1	0	1	0	1	0	2
Sustainability	1	2	1	1	0	1	0	1	1	2

Table 6 Title 1 School

There are no Title 1 schools at the middle school level that offer a CEM curriculum with topics in cost/estimating, equipment/power tools, and project management. County #1, County #2, and County #5 each have one Title 1 school that offers a CEM curriculum. There are no Title 1

schools at the high school level that offer a CEM curriculum, including Scheduling as a topic. Each county has a Title 1 school that offers a CEM curriculum.

**Discussion**

This study aims to understand the current state of the CEM curriculum at the pre-college level in the state of North Carolina. The assessment is focused on the course offerings within the top five populated counties. Moreover, this study identifies explicitly the course (course name), specific topics included within the course, and variations in course offerings based on school type (non-Title 1 and Title 1).

Overall, in the state of North Carolina, the CEM curriculum is present. At the middle school level and high school level CEM curriculum is offered for students. However, CEM courses are not offered equally throughout the state. In County #1, there is a high percentage of CEM curriculum course offerings compared to County #5, where there is a low percentage of CEM curriculum course offerings. County #1 has the largest student population and the lowest percentage of Title 1 schools. County #5 has the smallest student population and the second-highest percentage of Title 1 schools. In North Carolina, the student population decreases while the percentage of Title 1 schools increases.

There were no Title 1 schools at the middle school level that offered CEM curriculum in Counties #3 and #4. In County #1, there was the representation of all CEM topics throughout the CEM curriculum offering. However, as the percentage of Title 1 schools increased, counties offered CEM courses focused on Sustainability or no course.

There were no Title 1 schools at the high school level that offered CEM curriculum with Scheduling as a topic. Each county offered at least one course in the CEM curriculum. However, as the percentage of Title 1 schools increased, counties offered fewer CEM courses. County #1 has nine schools that offer a CEM curriculum compared to three schools in County #5.

**Conclusion**

The state of North Carolina has future workforce needs. Therefore, access to the CEM curriculum is essential to educate the future workforce, mainly including Title 1 students. According to Table 7, County #1, where the amount of CEM education courses is offered the most, the size of the construction workforce is the highest within the state at 32,473 people or 5.53% of the county's population.

Size of Construction Industry Workforce by County		
	Number of Workforce	Percentage of Workforce
County #1	32,473	5.53%
County #2	35,154	6.87%
County #3	12,038	4.51%
County #4	6,810	6.20%
County #5	5,591	5.49%

Table 7 Size of Construction Industry Workforce by County

According to Figure 6, County #2 and County #4 are the top two counties with the highest percentage of employment. However, those are not the top two that offer the most courses at the pre-college level.

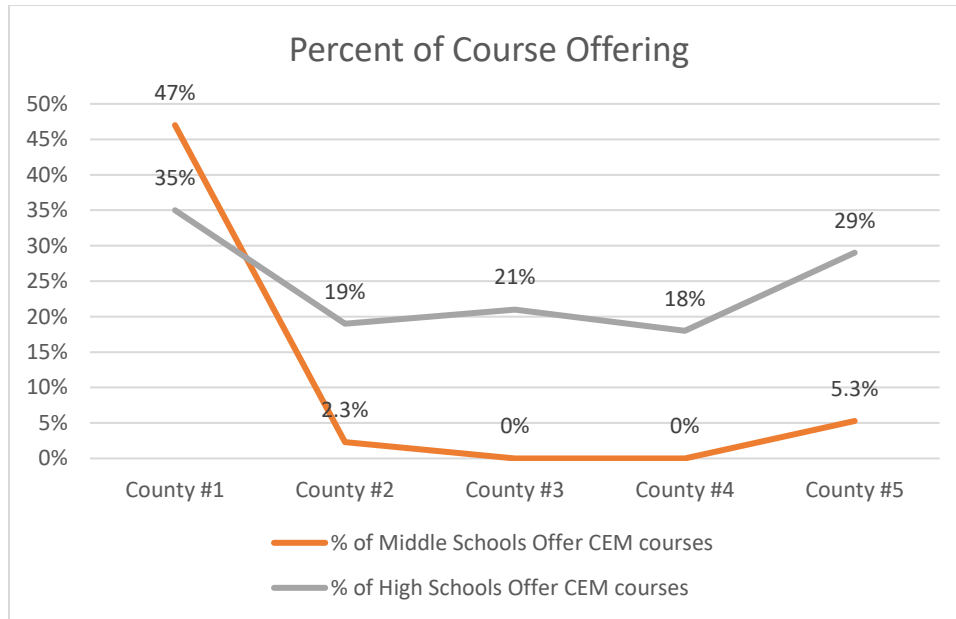


Figure 6 Percent of CEM Courses Offered per County

In Figure 6, the data also shows that CEM education is offered at a low percentage at the middle school level. CEM course offerings can improve at the middle school level in particularly in Counties #3 and #4, where it is not offered.

### Study Limitations

This study is limited only to the top five populated counties in North Carolina. Therefore, this study does not qualify as a national study of the current state of CEM curriculum offerings. The curriculum for this study is only the courses offered by the school for a grade used towards a pre-college level student's graduation credits. This study does not include seminars, short courses, and after-school programs for middle and high school students. This study uses data obtained during the academic year of 2019-2020 course offerings.

### Future Research

Future research for this study population is an exploratory study to identify the barriers towards implementing the CEM curriculum at the pre-college level. The data shows that the CEM curriculum is not offered equally throughout the state. Also, future research can explore the number of students who have had access to the CEM curriculum at the pre-college level and the retention of those students in the construction industry. This data will be generated from a longitudinal study of CEM education and its effects on the construction industry. The longitudinal study can also include the history of CEM education course offerings.

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## Appendix A

1. Contact Name
2. Position within School
3. School Name
4. Is this a Title 1 School?
5. School Location (State, County)
6. School type
  - a. Middle School
  - b. High School
7. During the academic year of 2019-2020, was any type of construction engineering and management education offered as a course(s)?
  - a. Yes
  - b. No
8. If yes, what is the name of the course(s) at your school for CEM education?
9. Are you able to provide a copy of the course planning tools (syllabus)?
  - a. Yes
  - b. No
10. If a course planning tool (syllabus) is not available, what are the topics in the CEM education course(s)?
  - a. Estimating
  - b. Equipment
  - c. Safety
  - d. BIM
  - e. Project Management
  - f. Scheduling
  - g. Sustainability
  - h. Materials & Methods
  - i. Contract Documents
11. Who would be the best person to contact within your school for further assistance with this study?
  - a. Contact Name
  - b. Contact Position
  - c. Contact Phone Number
  - d. Contact Email