AC 2011-1420: A SURVEY OF CONSTRUCTION-RELATED MATH SKILLS IN AN INTRODUCTORY-LEVEL CONSTRUCTION MANAGEMENT COURSE

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A Survey of Construction-Related Math Skills in an Introductory-Level Construction Management Course

Abstract

Construction management (CM) professionals use construction-related math skills daily in many aspects of their work. These math skills include adding and subtracting lengths, finding areas and volumes, and changing from one unit of measurement to another.

Many of these math skills are taught during elementary school, but numerous students are unable to confidently apply the skills several years later when they enter college, even though they may be eligible to take pre-calculus at that time.

This paper presents the results of a diagnostic construction-related math quiz given in a freshman level CM course over five different semesters, illustrating students' consistent difficulty performing these math skills. Since it is imperative that students have confidence applying construction-related math skills upon graduation with a construction management degree, this paper also proposes strategies to improve students' construction math skills.

Introduction

The 3Rs, Reading, wRiting and aRithmetic, have long been considered foundational skills in our education system, even though there has been much debate over the years about whether focusing on those skills is the only way or even the right way to educate children. However, in the workplace, skills such as reading, writing, and math still reign as essential skills[1].

The construction industry is no different; regardless of the type of job, basic reading, writing, and math skills are important[1, 2]. Construction management (CM) professionals use reading, writing and math skills in their jobs for many aspects of their daily work. While reading and writing are not trivial, this paper focuses on construction-related math skills. These math skills include adding and subtracting lengths, finding areas and volumes, and changing from one unit of measurement to another.

In the state of Idaho, these math skills are taught between third and ninth grade, per the current state content standards. Unfortunately, numerous students are unable to confidently apply the skills several years later when they enter college, even though they may be eligible to take pre-calculus at that time.

This paper presents the results of a diagnostic construction-related math quiz given in a freshman level CM course over five different semesters, illustrating students' consistent difficulty performing these math skills. Since it is imperative that students have confidence applying construction-related math skills upon graduation with a construction management degree, at its conclusion this paper also proposes strategies to improve students' construction math skills.
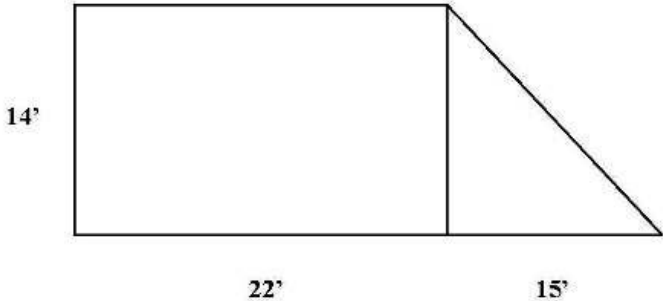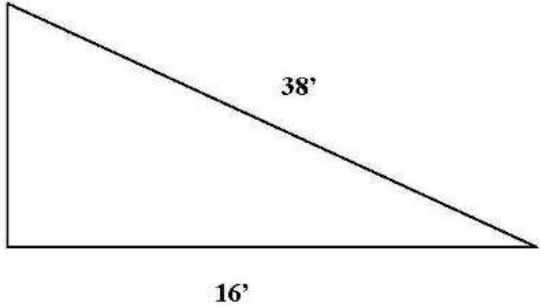
Methodology

The aim of the work presented in this paper is to illustrate students' consistent difficulty performing basic construction-related math skills. The researcher collected diagnostic math quiz data from students enrolled in a 100-level construction management course. The results of the data collection were analyzed to examine areas where students need additional assistance, with the long-term goal of creating a remedial course in construction-related math. The following sections describe the data collection and analysis in more detail.

Data Collection

At the start of each semester, students in a 100-level construction management course are asked to take a diagnostic math quiz as a homework assignment for which they receive no credit. The quiz is used to determine the level of construction-related math knowledge of the students in the class. Students who score 90% or better on the quiz are exempted from a two class period review of construction math. The students are allowed to use calculators and scratch paper and are asked to type their answers into an online quiz on the Blackboard course management system. There are 14 questions and there is a 40-minute time limit (although the system will let them go over this limit). The instructor of the course can complete the questions in less than 10 minutes, so the time allowed should be adequate for an average student. Students may only take the quiz once, but the system will allow them to pause their quiz and come back to it later if they choose. The quiz questions can be seen in Table 1. Also included in Table 1 are the math skills required to solve them and the approximate grade level the skills necessary to solve the problems are taught in the state of Idaho.

Table 1

#	Quiz Question	Math Skills Required	Approx. Grade Level Skills Taught
1	Convert 115 inches to feet and inches. (Example: 24" = 2'-0")	Unit conversion: inches to feet/inches	Grade 5
2	Convert 18'-2" to inches. (Example: 2'-0" = 24")	Unit conversion: feet/inches to inches	Grade 5
3	Convert 5 1/16" to decimal inches (round to 4 places). Example: 2 1/2" = 2.5"	Fraction to decimals: inch/fraction to decimal inches	Grade 5
4	Convert 0.4209" to the nearest common fraction that would be used in the construction industry. (Example: 0.5" = 1/2")	Decimals to fraction: decimal inches to inch/fraction	Grade 6
5	Convert 3 5/16" to decimals of feet. (Example: 3" = 0.25')	Fraction to decimals: inch/fraction to decimal feet	Grade 5
6	Convert 0.7305' to inches and fractions of an inch. (Example: 0.25' = 3")	Decimals to fraction: decimal feet to inch/fraction	Grade 6

#	Quiz Question	Math Skills Required	Approx. Grade Level Skills Taught
7	Add: 6'-3 3/16" + 8'-10 7/8" Give your answer in feet-and-inches-and-fractions.	Addition of lengths: feet/inches/fractions	Grade 5
8	Subtract: 12'-0 3/8" – 4'-10 9/16" Give your answer in feet-and-inches-and-fractions.	Subtraction of lengths: feet/inches/fractions	Grade 5
9	What is the area of a rectangle with Width = 4'-10" and Length = 7'-2"? Include units in your answer.	Area of rectangle, unit conversion: feet/inches to inches or feet or yards	Grade 6
10	What is the area of a circle with Diameter = 8'-3"? Include units in your answer.	Area of circle, unit conversion: feet/inches to inches or feet or yards	Grade 6
11	What is the area of a triangle with Altitude =10'-10" and Base = 15'-4"? Include units in your answer.	Area of triangle, unit conversion: feet/inches to inches or feet or yards	Grade 6
12	How many cubic feet are in a cubic yard?	Unit conversion: cubic feet to cubic yard	Grade 7
13	How many cubic yards of concrete are needed for the 6" thick slab below? 14' 22' 15'	Volume of rectangle and triangle, unit conversion to cubic yards	Grade 8
14	Determine the unknown length. Give the answer in feet and tenths. 38' 16'	Pythagorean Theorem	Grade 9

Quizzes are graded quite rigorously by the instructor, as this is a diagnostic quiz to determine what students know, and more importantly what they do not know. Questions are counted wrong if they have the wrong numerical answer, but they are also counted wrong if they have the wrong units (such as a given answer of 35.4 inches when the correct answer is 35.4 feet), inappropriate units (such as an answer like 54 ft^2 3¼ in^2 for an area calculation), or no units. Students are warned beforehand that the instructor will be very picky about the answers when grading, and the only comment made about units is that students should include units in their answers. It is left to the student to determine what an appropriate unit would be for each question.

Data Analysis

Quiz data has been collected for five semesters (n = 31, 48, 36, 34, 40, total N=189). Data of interest include the questions students answered incorrectly (see Figure 1) and their grades for this quiz (see Figure 2). When looking at these figures, it becomes quite obvious that students consistently have issues with these basic types of math skills.
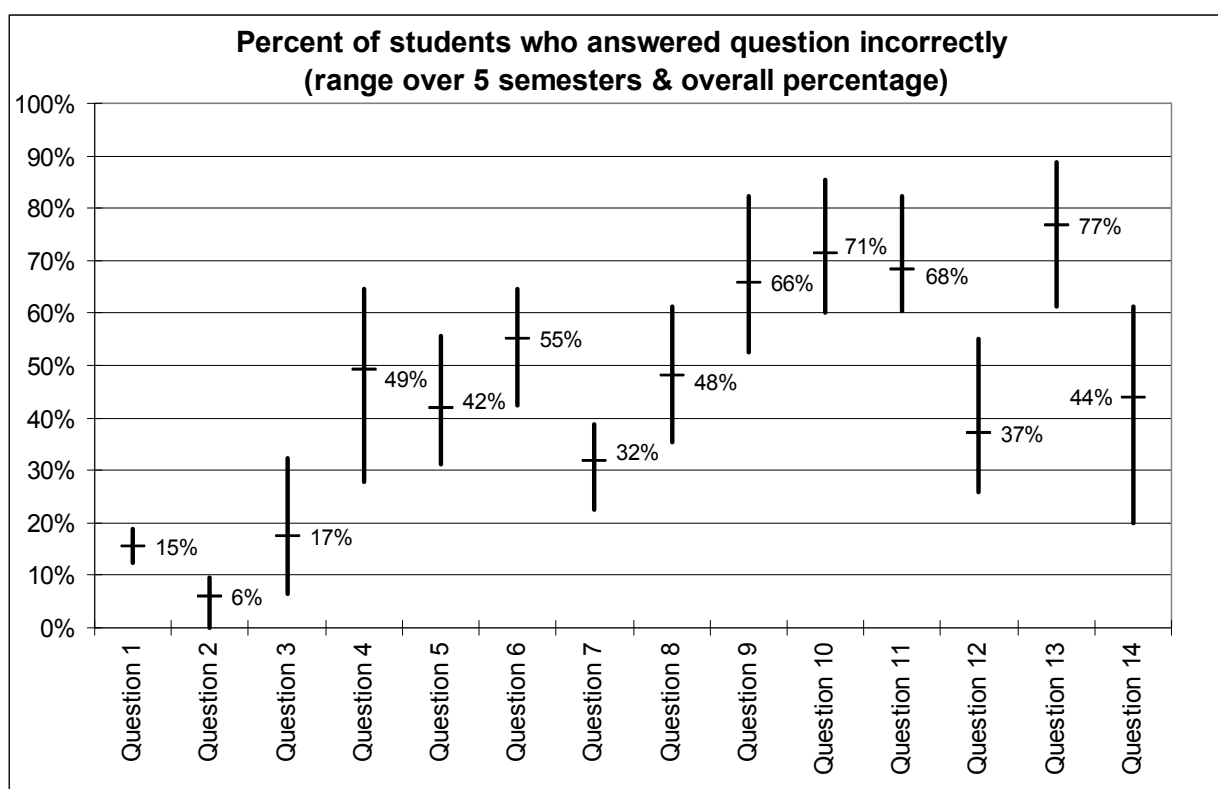

Figure 1

Most students were able to correctly answer a handful of questions. Conversion from feet/inches to inches (Question 2) gives students the least amount of trouble on the quiz, followed by conversion from inches to feet/inches (Question 1) and conversion from inches/fractions to decimal inches (Question 3). These are all questions that a fifth grader should be able to answer correctly. The other fifth grade level questions (Questions 5, 7, and 8) were harder for students, but overall more than 50% of the students were able to correctly answer these questions.

Interestingly, Question 12 (seventh grade level) and Question 14 (ninth grade level) were also answered correctly by more than 50% of the students.

While the preceding statistics are concerning, given the number of students who answered these questions incorrectly, the number of students unable to correctly answer the remaining questions is even more alarming. Questions 9, 10, and 11, finding areas of rectangles, circles, and triangles using appropriate units (sixth grade level), and Question 13, finding the volume of a combined rectangular and triangular shape using appropriate units (eighth grade level), were answered incorrectly by more than 2/3 of the students.
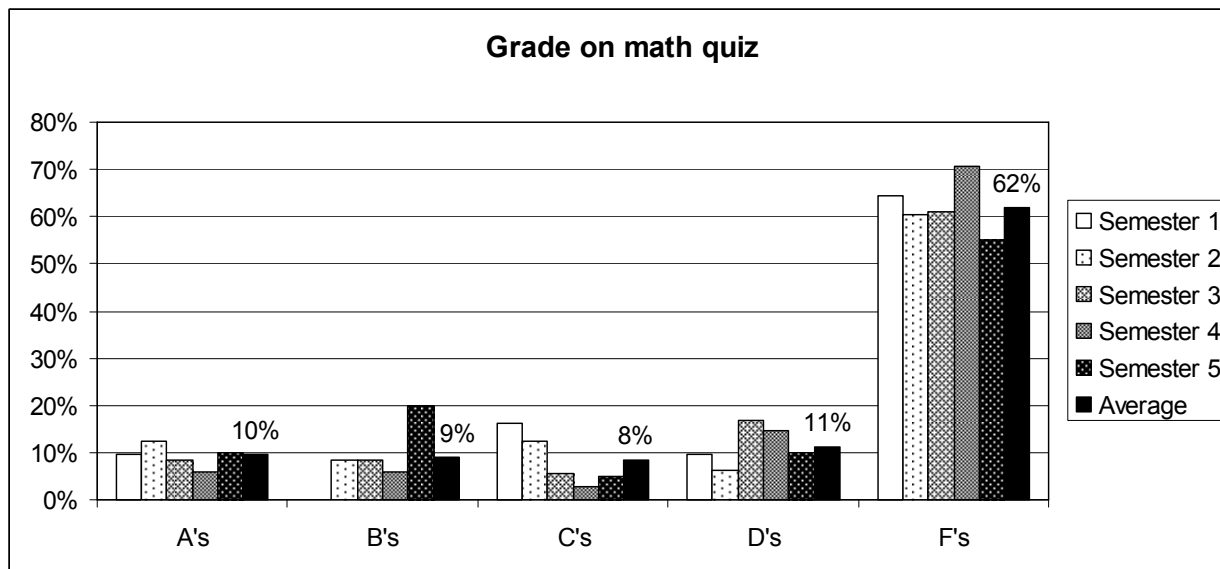

Figure 2

As can be seen in Figure 2, nearly ¾ of the students (73%) received a D or F grade (less than 70% score) on this diagnostic quiz during the five semesters data has been collected.

Discussion

Given this disturbing data, what does it mean and what should be done? There are a few factors that may contribute to these results. First, students come into this course with varying degrees of math skills. The prerequisite for this course is MATH 108, titled "Intermediate Algebra," so all students have passed that course with a C- or better grade and should be enrolled in pre-calculus as a minimum. Some students enrolled in the 100-level CM course have completed pre-calculus already, and there are occasionally students who have already completed the survey of calculus course, which is the last math course required for the CM degree at Boise State University. One would presume that those in higher level math courses and those with higher grades in math would score well on this quiz, whereas those in lower level math courses and/or had lower grades in math would score lower on the quiz. This factor has not yet been examined in detail, but certainly is worthy of study.

However, the poor showing on math skills from elementary and middle school really cannot be explained by the varying math courses that students have had previous to this quiz. More likely, students have been exposed to these math skills, but cannot remember them, do not truly understand them, or they have not had to put many skills together to solve a single problem such as those in the quiz[3-5]. Also, in some instances it seems that the issue relates to giving the students measurements in mixed units (feet and inches and fractions). Many of the students give answers that imply unfamiliarity with these mixed units, although using length measurements from a ruler are introduced as part of the third grade math content and that is built upon in succeeding grades.

A lack of confidence in math is another factor that may be a cause for the poor quiz scores. A lack of confidence can be a self-fulfilling prophecy in math[6-8]. Students have no confidence in their skills, so they avoid math, and their skills consequently do not improve, lowering their confidence even more.

Regardless of the source of the problem, a solution is needed. These students must be able to confidently use math skills such as those required on the diagnostic quiz upon graduation. For some students, a review of the appropriate skills is enough. For the remainder, some sort of remediation is necessary for them to be successful in their degree program. Remedial math is not new[9, 10], although it is certainly in the news more today than ever before. Figures vary, but some claim that as many as 70% of students entering college have to take a remedial math course[3, 10, 11] and many of those students took three or four years of math in high school[3]. Without extra help, particularly in math, many students will flunk out or give up on their college education.

There have been several strategies suggested in the literature to help these struggling students with math. Peer tutoring is one strategy that seems to make a difference, particularly if the peers also struggled with math at one time[12, 13]. Another strategy is to reduce math anxiety levels by helping students remove emotion from the equation[6], having instructors capable of lots of patience and the ability to explain an idea in numerous ways[14], and including contextual information[8, 15]. These strategies have been successful in numerous contexts outside of construction, so it is likely that they would also be successful with construction management students.

Conclusions

The results presented here are an indication that freshman-level students in the CM program at Boise State University are consistently having difficulty with construction-related math skills. The results are consistent with other studies that indicate high percentages of entering college students are not prepared for college-level work and require remedial coursework. However, none of these other studies looked specifically at CM students or construction-related math. The results from this current work warrant continued study in more depth, particularly to determine whether the problem extends to freshman-level CM students at other colleges or whether it is limited to only this university. It would also be beneficial to collect some additional data, such as what math courses have been completed and the respective grades prior to taking the diagnostic quiz, as well as how and when students learn these math skills if no formal

remediation is provided. Finally, it would be valuable to examine the strategies that have been successful in other contexts and determine their successfulness with construction management students.

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