Have Math Skills Been Outsourced?

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ABSTRACT

It has been observed that deficiencies exist in college students' abilities to apply fundamental mathematical skills. This research study assessed the comprehension level of some basic mathematical skills of students enrolled in a sophomore level production course. Skills measured include, among others, the order of arithmetic operations, decimal and percent conversion, solving of algebraic expressions, and evaluation of formulas. Data analysis indicated deficiencies in several areas.

INTRODUCTION

It appears, through personal observation and comments by colleagues for many years, that college students have forgotten how to apply fundamental mathematical skills. Informal evaluation of various mathematical skills shows that deficiencies persist. Unfortunately, this problem is not limited to this University. According to a report issued by the American Institutes for Research, "fewer than half of today's college students graduate with broad proficiency in mathematics and reading" (Lipka, 2006). Moreover, in the state of Arkansas, 45.1% of college freshmen — that's almost 9,000 students — in the fall 2007 took non-credit remedial math because of low scores on the ACT college entrance exam (Manthey, 2008)[1]. Two decades ago, a director of the University's Academic Development Office advised that college bound students should:

> take all the math they can get in high school. … It is the nature of the curriculum at the University today that adequate preparation in math is a requirement for success. If there's one skill a student should have, it's math. (Adviser Stresses Academic Preparation, 1986, pp. 1-2)

O'Dell (1977) measured the mathematical mastery for some "psychology majors in a medium to large university, mainly sophomores and juniors." He reported:

* many of his students could not keep track of algebraic signs,
* the placement of decimal points appeared to be a "nightmare,"
* a surprising difficulty with the substitution of numbers,
* the implicit order of combined arithmetic operations seemed to be "foreign," and
* solution of an algebraic equation was difficult.

Interestingly, his results are quite similar to those obtained 40 years earlier by Brown (1933).

[1] Also see Hilliard (2005).

If faculty make the assumption, as presumably most do, that their students can handle such skills without difficulty, they may be mildly surprised sometime during the semester. (Don't attempt to argue that calculators make this issue mute!)

The objective of this research study was to assess business students' mathematical preparedness. Among the skills measured were the order of arithmetic operations, decimal and percent conversion, solving of algebraic expressions, evaluation of formulas, and determining the equation of a line.

METHOD

In order to determine the degree to which the students possessed or lacked the necessary skills, a set of review problems was prepared. The premise in developing the problems was to include computational and manipulative skills deemed useful in the course. The problems appear in Appendix A and Appendix B. The first question employs simple operations of arithmetic. However, the five problems require observance of the order of arithmetic operations. Questions 2 through 5 address decimal and percent conversions. Question 6 requires the solving of algebraic expressions; question 7 requires numerical substitution into and evaluation of formulas. Question 8 uses coordinate geometry. Finally, it is noted that the computational and manipulative skills necessary to solve the questions should be within the ability of a student completing a 10th grade math requirement.

The sample consisted of students attending a sophomore level production course. Two of the prerequisite classes are Finite Math and Data Analysis. The set of review problems in Appendix A was distributed unannounced during the second day of class; the time allowed to complete these problems was about ten minutes. Calculators were not permitted. The problems in Appendix B were distributed unannounced prior to discussion of forecasting methods, several weeks into the semester; about five minutes were allowed to complete these problems[2]. Data analysis determined simple percentages of incorrect responses in order to indicate deficiencies. Grading of the responses was either correct or incorrect. Unsimplified substitutions of numbers into formulas and of square roots were marked incorrect. A "right answer" to questions 8b and 8c was marked correct only if the line in 8a was drawn correctly.

RESULTS

Approximately 63% of the students answering the set of review problems in Appendix A were male. Twelve (13%) students correctly answered all 15 problems, with the least number of correct answers being 3 (20% correct). The mean number correct was 11.5 (77% correct); the median number correct was 12 (or 80% correct). Thus, the test performance of the students was not very satisfactory with respect to the ability to apply these fundamental mathematical skills. The distribution of scores is shown in Table 1. Interesting, 32% of the students' scores were an "A" (i.e., at least 90% correct answers); but 18% were "D" and 14% were "F".

[2] The problems in the two appendices were administered in different semesters. The number of students submitting the problems in Appendix A and in Appendix B was 91 and 39, respectively. The names of Appendix B students were not obtained.

Number (and Percent) of Correct Answers	Percent of Students
15 (100%)	13.2
14 (93.3%)	18.7
13 (86.7%)	11.0
12 (80.0%)	12.1
11 (73.3%)	13.2
10 (66.7%)	11.0
9 (60.0%)	6.6
8 (53.3%)	5.5
7 (46.7%)	1.1
6 (40.0%)	2.2
5 (33.3%)	3.3
4 (26.7%)	1.1
3 (20.0%)	1.1
Total	100

Table 1: Distribution of test scores for problems in Appendix A

No practical differences existed between male and female scores. The mean number correct for males was 11.3 (76% correct) and for females was 11.8 (or 79% correct).

Twenty-seven (69%) students correctly answered all three problems in Appendix B. Five (13%) were not able to draw the line correctly. Twelve (31%) could not determine the equation of the line.

Table 2 reports the percent of correct, incorrect, and omitted responses for the problems in both appendices. In addition, typical mistakes are noted. The number of times a problem was omitted may reflect either a definite lack of knowledge or perceived level of difficulty of how to solve the problem. It was obvious that some mistakes were attributed to carelessness such as reading one symbol of operation as another and transposing digits of the correct answer.

The problems for which application of the basic skills proved to be the most troublesome — that is, problems missed by at least 20% of the students — were implicit order of arithmetic operations (i.e., problems 1(a), 1(b), 1(d), and 1(e)), solution of an algebraic equation (i.e., problems 6(a) through 6(d)), evaluation of formulas including failure to take square roots (i.e., problems 7(a) and 7(b)), and determining the equation of a line (i.e., problem 8(c)). These skills also were identified by Brown (1933) and O'Dell (1977) as areas of deficiency. Unfortunately, faculty make the assumption, perhaps erroneously, that their students can handle such concepts with no difficulty upon entering various courses. Nothing appears to be more wrong!

Problem	Percent Correct	Percent Incorrect	Percent Omitted	Correct Answer	Typical Mistakes
1 (a)	72.5	27.5	0	43	30
1 (b)	68.1	31.9	0	−26	±10
1 (c)	91.2	8.8	0	2.5	1
1 (d)	60.4	39.6	0	−22	56
1 (e)	79.1	20.9	0	15	21
2	93.4	6.6	0	1%	10%
3	94.5	5.5	0	75%	.75
4	98.9	1.1	0	.03	.3
5	86.8	13.2	2.2	25%	.25; ¼
6 (a)	75.8	24.2	11.0	10	—
6 (b)	79.1	20.9	4.4	1250	125
6 (c)	47.3	52.7	25.3	225	15; $\sqrt{15}$
6 (d)	65.9	34.1	17.6	M + SZ	—
7 (a)	76.9	23.1	7.7	14	—
7 (b)	60.4	39.6	17.6	6	36; 68; $\sqrt{68}$
8 (a)	87.2	12.8	2.6	—	—
8 (b)	84.6	15.4	5.1	4	—
8 (c)	69.2	30.8	15.4	y = ½ x + 3	—

Table 2: Percent of correct, incorrect, and omitted responses and typical mistakes

CONCLUSION

It is concluded, based on personal observation and concerns expressed by other faculty, that many college students exhibit a low level of basic mathematical skills. While one believes that a student who completes several high school and college math courses[3] should not have such deficiencies, this assumption does not seem correct. Hence, solutions of problems encountered in a variety of college courses require mathematical skills which students often do not possess. There is no doubt that students, who lack mastery of these concepts, possess deficiencies which place them at a disadvantage in learning material dependent upon these concepts.

This author believes such math deficiencies have a direct impact on effective teaching, in addition to partially explaining students' performances in various university courses. It may also

[3] The University requires four units of high school mathematics which must be chosen from Algebra I, Geometry, Algebra II, Trigonometry, Pre-calculus, and Calculus. The college prerequisites include College Algebra, Finite Math, and Data Analysis courses.

help to explain the high drop rates in freshman and sophomore math and "math-based" courses. For example, College Algebra, Finite Math, Survey of Calculus, and Data Analysis have a significant number of drops, ranging from 20% to 40%. One reason may be deficiencies in fundamental mathematical skills. Students who are poorly trained in mathematics give rise to serious educational problems. Fidler (1991) observed that the freshman year is the time of greatest attrition.

The results of this study suggest that mathematics is one academic ability variable which may affect attrition. While it can be argued that mental ability is more important than mathematical training, it is important to recognize that there are a considerable number of students who are not adequately prepared. Faculty need to be prepared for this deficiency and to be prepared to assist students to overcome these areas of weakness. Review problems, which address skills such as those discussed herein as well as other skills (e.g., expected value, z score, normal distribution probability) deemed useful in the course, allow students to identify their areas of weakness. In addition, review problems provide an opportunity for students to improve their academic abilities and, in turn, improve their course grades.

APPENDIX A

1. Perform the indicated operations for each of the following expressions <u>without using a calculator</u>.

   (a) $26 + 34 / 2 =$

   (b) $29 - 37 - 18 =$

   (c) $3 / 2 + 1 =$

   (d) $6 - 2 \times 14 =$

   (e) $3 + 4\,(20 - 17) =$

2. Express .01 as a percentage.

3. Express 3/4 as a percentage.

4. Express 3 percent as a decimal.

5. 2 is what percentage of 8?

6. Solve each of the following expressions for x.

   (a) $\frac{39}{3+x} = 3$

   (b) $11x + 3000 = 7x + 8000$

(c) $\frac{3}{5} = \frac{9}{\sqrt{x}}$

(d) $Z = \frac{X - M}{S}$

7. Evaluate each of the following formulas <u>without using a calculator</u> assuming that A = 108, C = −4, N = 6, and S = 312.

(a) $M = \frac{A}{N} + C$

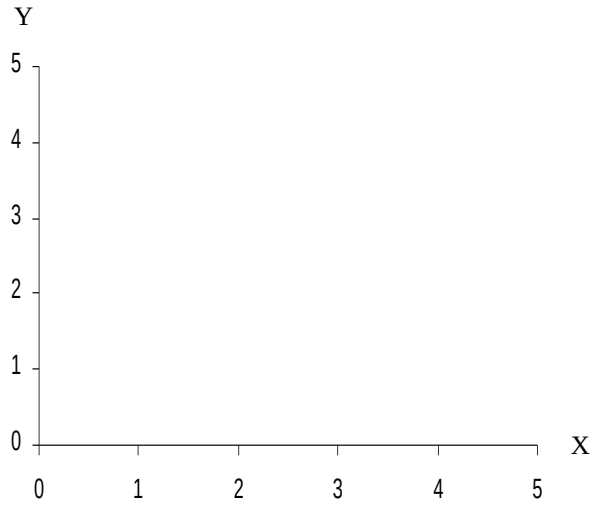
(b) $X = \sqrt{\frac{S}{N} - C^2}$

APPENDIX B

8. (a) On the graph below, draw a straight line through the points (x = 0, y = 3) and (x = 4, y = 5).

(b) What is the value of y when x = 2?

(c) Write the equation of the straight line you drew.



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