# SOME EARLY OBSERVATIONS FROM AN ASSESSMENT OF RETAINED MATHEMATICS SKILLS AMONG BUSINESS STATISTICS STUDENTS 

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#### Abstract

This paper reports some of the findings from an assessment of basic mathematic skills among business students. The apparent lack of retention of material from arithmetic and elementary algebra is of concern. The importance of context, especially for older returning students, is highlighted.


## BACKGROUND

Weak quantitative reasoning skills have been suggested as a contributing factor in the loss of academic standing among undergraduate students [6]. In the mid 1990's, Hunt and Lawson [7] noted a significant decline in the mathematical skills of undergraduate engineering students over a five year period. Furthermore, Sutherland and Pozzl [10] found that even the most mathematically able students were having difficulty with routine calculations. Thus, Armstrong and Croft [1] recommended that universities may need to make adaptations to their courses to counter the apparent shortfall in basic math skills. The assessment reported in this paper began as an attempt to isolate which skills fit this category among current undergraduate business students.

All students enrolled in the one of the basic business statistics courses at either the main residential campus or the downtown commuter campus at Eastern Washington University were given the same anonymous assessment at the beginning of the first class meeting in January of 2004. These five courses were:
A. First quarter statistics at the main campus -70 undergraduates with a mean age of 23.8
B. Second quarter statistics at the main campus - 56 undergraduates with a mean age of 23.3
C. First quarter statistics at the downtown campus - 52 undergraduates with a mean age of 26.5
D. Second quarter statistics at the downtown campus - 60 undergraduates with a mean age of 27.4
E. PreMBA statistics at the downtown campus - 23 post-bachelors students with a mean age of 31.8 Calculators were allowed and the time for completion was 30 minutes. Mean ages for each course were obtained for the entire class roster through the student information system at a later date. As the purpose of this assessment was to determine which basic mathematical skills were not being retained, the students were not informed of this assessment in advance to prevent review and preparation.

As all of the courses being assessed required clearance of the university mathematics proficiency requirement prior to enrollment, only material at or below this level was included [3]. In particular, arithmetic and elementary algebra were especially emphasized on this instrument as they have long been recognized as essential basic skills for entry-level undergraduate students [4]. The actual assessment items along with the proportion of students unable to correctly respond are found in the next section. Equivalent answers, such as $-22 / 3$ for $-7.333 \ldots$, were accepted as correct.

## DISCUSSION

The instrument and results are in table 1 at the top of the next page. Students do not appear to be keeping the skills and knowledge gained during their basic mathematics preparation. In particular:

| Directions for 1 through 11 - Solve for y |  | Proportion of students unable to answer correctly |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Problems | Answers | $\begin{aligned} & 0 \\ & 0 \\ & 0.0 \\ & \ddot{\ddot{O}} \end{aligned}$ | $\begin{aligned} & \text { O} \\ & \text { O} \\ & \text { B } \\ & \underset{D}{2} \end{aligned}$ | $\begin{aligned} & \text { O} \\ & \text { O} \\ & \vdots \\ & \dot{W} \\ & \infty \end{aligned}$ | $\begin{aligned} & \text { O} \\ & \text { O} \\ & \underset{O}{8} \\ & 0 \end{aligned}$ | O O 0 0 0 | 2 0 O D T1 |
| 1. $y=1+2 \times 3$ | 7 | . 1533 | . 1000 | . 0357 | . 2115 | . 1500 | . 4783 |
| 2. $y=-5 \times \frac{4}{6}-\frac{6+10}{3+1}$ | -7.333... | . 4444 | . 4286 | . 3571 | . 4423 | . 4333 | . 7391 |
| 3. $y=\left(3 \times 10^{-3}\right)\left(4 \times 10^{5}\right)$ | 1200 | . 3678 | . 3143 | . 1964 | . 4423 | . 4000 | . 6957 |
| 4. $y=3\left(-4 m^{2}+7\right)-\left(5 m^{2}-6\right)$ | $-17 m^{2}+27$ | . 5211 | . 5714 | . 2857 | . 5385 | . 5833 | . 7391 |
| 5. $4 y-(y-2)=7-2(3 y-4)$ | 13/9 | . 5172 | . 6143 | . 4643 | . 3846 | . 5000 | . 6957 |
| 6. $z=\frac{1}{2}(x+y)$ | 2z-x | . 6552 | . 7000 | . 5357 | . 6538 | . 6500 | . 8261 |
| 7. $\frac{8}{y-2}-\frac{13}{2}=\frac{3}{2 y-4}$ | 3 | . 8812 | . 8286 | . 8571 | . 9423 | . 9167 | . 8696 |
| 8. $15-\frac{2}{3} y>-5$ | $\mathrm{y}<30$ | . 7280 | . 7000 | . 6607 | . 7308 | . 8167 | . 7391 |
| 9. $\|2 y-5\|<7$ | $-1<y<6$ | . 9234 | . 9286 | . 9286 | . 9231 | . 9167 | . 9130 |
| 10. $2 \sqrt{y-8}=-3$ | none | . 9732 | . 9571 | . 9821 | . 9808 | . 9833 | . 9565 |
| 11. $\left\{\begin{array}{l}3 x-5 y=19 \\ 2 x-4 y=16\end{array}\right.$ | $\begin{gathered} y=-5 \\ (x=-2) \end{gathered}$ | . 6667 | . 6143 | . 5536 | . 7308 | . 7167 | . 8261 |
| 12. If you can travel 25 miles in 35 minutes, at what speed in miles per hour (correct to three decimal places) are you driving? | $\begin{gathered} 42.857 \\ \mathrm{mph} \end{gathered}$ | . 6054 | . 5143 | . 5893 | . 6154 | . 6833 | . 6957 |
| 13. If a recipe requires $21 / 4$ cups of flour to make 36 cookies, how much flour is needed to make 60 cookies? | $33 / 4$ cups | . 3831 | . 3000 | . 4107 | . 4423 | . 4000 | . 3913 |
| 14. Sue bought a coat on sale at $15 \%$ off the regular price and paid $\$ 71.40$ for it. What was the regular price of the coat? | \$84 | . 5594 | . 5571 | . 4821 | . 6346 | . 5667 | . 5652 |
| 15. Catherine works two part time jobs: one pays $\$ 7$ per hour and the other pays $\$ 10$ per hour. Last week, she worked a total of 32 hours and made a total of $\$ 278$. How many hours did she work at each job? | $\begin{gathered} 14 \mathrm{hr} @ \\ \$ 7 / \mathrm{hr} \\ 18 \mathrm{hr} @ \\ \$ 10 / \mathrm{hr} \end{gathered}$ | . 5326 | . 4714 | . 4464 | . 6346 | . 6167 | . 4783 |

Table 1: The assessment instrument and composite results

1. It seems that mathematical notation beyond simple arithmetic is not being retained by many students. At least one-third of all students were unable to answer questions 2 and 3 correctly. The reluctance of students to multiply fractions mentioned by Mestre [8] may be one factor in play here.
2. The older returning post-bachelors students performed worse than the undergraduate students on the basic material (questions 1 through 5) but this difference disappeared with the more difficult problems (questions 6 through 11). As the proportion unable to answer correctly increases as the mean age increases, it is suspected that an increase in the length of time since completion of the
prerequisite material may be a factor. However, the instrument used here was not designed to examine this possibility.
3. Mathematical notation beyond simple algebra is less likely to be retained. More than half of all students were unable to answer questions 6 through 11 correctly. Questioning students on their need for help in these topics may not be useful as Armstrong and Croft [1] noted that even though many students do not believe they need considerable help they also lack basic ability and knowledge in mathematics.
4. Students had difficulty applying ratios in non-everyday contexts. About one-third of all students were unable to answer the cooking problem correctly, while more than half were unable to answer the unit change and discount problems correctly. Mestre [8] believes that students begin their quantitative classes with mathematical misconceptions they have formed from their everyday experiences. One of his key finding possibly applicable here is that most college students in remedial math courses have the misconception that multiplication is used for computing increases and subtraction is used for computing decreases.
5. Context appears to be especially important for the older returning post-bachelors students. Note the significant and dramatic difference in the proportion of students unable to answer the simultaneous equation problems (questions 11 and 15) correctly in course E. It appears that reasoning skills are intact yet the meaning of the formal notation seems to be lost. Mestre's [8] discussion on overcoming mathematical misconceptions demonstrates the importance of context for the low skilled students. Perhaps this method of inducing conflict by probing for qualitative, then quantitative, and finally conceptual understanding by tying the material being studied to everyday experiences should be extended to returning students as well.
6. All of the students in the courses studied had the material on the assessment instrument as a prerequisite to enrollment, yet many failed to retain much of it. One factor possibly influencing this is the fact that students who overcome a mathematical misconception will often return to it shortly after the end of ordinary instruction [5]. Thus, using completion of particular mathematics courses alone to ensure mathematical proficiency may not be sufficient. As Ratcliff and Yaeger [9] noted that "all quantitative reasoning development did not occur exclusively in mathematics classes" and that the "development of general learned abilities was not confined to the lower division," the initiatives at many universities to incorporate mathematics across the curriculum may help enhance the retention of these basic skills.

## FUTURE DIRECTIONS

As the assessment reported was the first iteration of an ongoing process, the insights gained are to be used to refine the instrument. First, the students will be asked to self-report age, the amount of time and level of their last mathematics course, and the amount of time and level of their last course with a significant quantitative component. These latter classes would include those that heavily use mathematics but are not solely about mathematics, such as accounting, finance, statistics or sciences. Next, more notation-context pairs of questions such as questions 11 and 15 above need to be added to further isolate the concepts for which context is extremely critical. Finally, questions designed to isolate pertinent mathematical misconceptions [2] are also being considered. The revised version of this assessment is to be implemented in the same five classes in January 2005. It is hoped that the second iteration of this assessment process will provide greater insights than that of the current iteration which highlighted the need for context over formal notation.

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