Assessing the Basic Math Skills
of First-Year Doctor of Pharmacy Students

David A. Latif
Joseph A. Grillo

ABSTRACT. The objective of this study was to assess the basic math skills of two classes of doctor of pharmacy students at a private southeastern school of pharmacy. The Basic Math Skills Test (BMST) was used to assess 121 first-year doctor of pharmacy students from the classes of 2003 and 2004. All entering students present during orientation week were tested using the BMST. The BMST consists of a 50-question, timed math test that measures basic math skills in 9 different areas. The areas and level of difficulty were taken from an eighth-grade mathematics textbook. In accordance with the recommendation of the developer, students were allotted 20 minutes to complete the exam. Results revealed that the cumulative mean score on the BMST of this sample was 68.90%. Implications of the study: (1) poor basic math skills impede successful completion of the pharmacy curriculum and (2) poor basic math skills may increase the probabilities of mathematical mistakes when filling prescriptions in pharmacy practice. Two alternative educational interventions are advanced for remediating those students who are identified as being deficient in basic mathematics (those who achieve a percentage score of less than 70). *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-HAWORTH. E-mail address: <getinfo@haworthpressinc.com> Website: <http://www.HaworthPress.com> © 2002 by The Haworth Press, Inc. All rights reserved.]*

KEYWORDS. Basic Math Skills Test (BMST), remediation, timed test

David A. Latif, M.B.A., Ph.D., is Assistant Professor, Department of Biopharmaceutical Sciences, and Joseph A. Grillo, Pharm.D., is Assistant Professor, Department of Pharmacy Practice, Bernard J. Dunn School of Pharmacy, Shenandoah University, 1460 University Drive, Winchester, VA 22601.

Address correspondence to: Dr. Latif at the above address (E-mail: dlatif@su.edu).

INTRODUCTION

Mathematical abilities are necessary skills in both pharmacy school and pharmacy practice (1). Although some pharmaceutical calculations such as those used in clinical pharmacokinetics require advanced mathematical skills, most courses in pharmacy schools and in pharmacy practice require only basic math skills. These skills include individualized patient dosing, extemporaneous compounding of new formulations, and dispensing of drugs in accordance with their directions for use (1).

Empirical investigations of college students have demonstrated that American students may have significant mathematical deficiencies (2-8). For example, entering college students in the late 1970s and early 1980s revealed low proficiency in basic mathematical skills (2). A comprehensive study of the New Jersey college system tested the basic mathematical and algebraic skills of 47,725 students. It was reported that 30% were deemed to be proficient in basic mathematic computation, while only 11% were proficient in algebra skills (3). The report concluded that nearly one-half of entering college students in New Jersey were in need of intense remediation in basic math skills. More recent findings suggest that this trend is continuing. A 1996 investigation by the National Assessment of Educational Progress (NAEP) revealed that only 60% of 17-year-old students had mastered simple fractions, decimals, simple percentages, and simple linear equations (4).

In the health professions, nursing has reported concerns about basic mathematical deficiencies. A 1984 study by Bindler et al. revealed that up to 38% of 700 junior level baccalaureate nursing students were unable to score 70% or better on a "Mathematics Proficiency Exam" (2). McCann-Flynn et al. reported that the mean score of 64 female junior nursing students on a medication calculations test was 73% (5).

A 1996 investigation by Pozehl tested 56 nursing students and 56 students majoring in other disciplines on basic math skills and anxiety (6). A 70% pass level was required to pass the math examination. It was reported that nursing students scored a mean of 59.8% on the math examination, while nonnursing students scored a mean of 72%.

How important are basic math skills in preventing medication errors? There is some anecdotal evidence to suggest that these skills are important to health professionals. For example, Dexter and Applegate cite a specific instance of a just graduated registered nurse who administered one half grain of morphine instead of the one eighth grain that was ordered (7). Another study of 43 pediatricians, nurses, and pharmacists re-

garding the testing for errors resulting from the calculation of drug doses for neonatal intensive care infants demonstrated that double-digit percentage errors were made, which would have resulted in an administration of ten times the prescribed dose (8).

Two health profession studies have examined the influence calculators have on performance. Shockley et al. examined the effect the use of calculators had on a dosage calculations examination (9). The authors reported that there was a significant difference in both arithmetic and conceptual skills ability when those tested used calculators. Calculator use was associated with improved arithmetic performance but diminished conceptual skills performance (9). A subsequent pharmacy study corroborated Shockley et al. by demonstrating that pharmacy students in a pharmacy calculations course scored higher when allowed to use calculators (10). However, the author suggested that, without an understanding of basic math, pharmacists who miscalculate a dose on a calculator by pushing a wrong button might not realize that the obtained answer could not possibly be correct.

Because of the widespread use of basic math in pharmacy practice, doctor of pharmacy students are expected to possess basic mathematical skills. Schools of pharmacy attempt to ensure these skills in two ways. First, many pharmacy schools require a minimum grade point average (GPA) in prerequisite courses such as general mathematics and calculus (11).

The second way in which pharmacy schools attempt to ensure basic math skills is through the assessment of standardized test scores during the admissions process. The national standardized test used by many pharmacy school admission committees is the Pharmacy College Admissions Test (PCAT™). The Quantitative Ability Section (PCAT-QP) is composed of arithmetic skills and mathematical reasoning sections, which include a total of 65 questions on fractions, decimals, percentages, and algebraic and geometric problem solving (11). Raw scores for each PCAT section are converted to scaled scores and percentile ranks based on the performance of a norm group. The quantitative ability scaled scores of the norm group range from 102 to 351, with a mean of 202.13 ± 27.42 (6).

The present investigation had one major objective: to assess the basic math skills of two classes of doctor of pharmacy students at a private southeastern school of pharmacy.

The remainder of this paper is organized as follows. First, the methods of this investigation are described and the results are reported. Next,

the results are discussed and two proposed educational interventions are advanced to improve the basic mathematic skills of those students identified as being deficient in these skills. Finally, implications of this study are discussed along with its limitations and possible future research directions.

METHODS

This investigation used a convenience sample comprising two classes of entering doctor of pharmacy students at a four-year-old, private southeastern school of pharmacy. Institutional Review Board approval was obtained prior to beginning the investigation. Two classes of doctor of pharmacy students, the classes of 2003 and 2004, were assessed on their basic math skills during August of 1999 and 2000, respectively. All first professional year students attending orientation were required to take the BMST as part of the orientation process. One hundred twenty-one doctor of pharmacy students took the BMST during August of 1999 and August of 2000.

The classes of 2003 and 2004 were assessed on basic math skills prior to commencement of their respective first professional years. The purpose was to identify what, if any, problems first-year pharmacy students have concerning basic math skills. Based on the results of the basic math skills assessment, the need for a "math mentor" program to address the remedial math education needs of entering doctor of pharmacy candidates could be examined.

All entering students present during orientation week were tested using the Basic Math Skills Test (BMST) (12). The BMST consists of a 50-question, timed math test that measures basic math skills in nine different areas (addition, subtraction, multiplication, division, working with fractions, percentages, converting fractions to decimals, calculating interest rates, and solving for an unknown). The areas and level of difficulty were taken from an eighth-grade mathematics textbook. This instrument has been shown to be both reliable and valid (12). During the BMST, students are permitted to use a pencil and paper for calculations, but calculators are not permitted. In accordance with the recommendation of the developer, students were allotted 20 minutes to complete the exam. The testing conditions, including the time limit, were consistent with those used to validate the instrument (12). Descriptive statistical analysis was performed using SPSS™ Version 10.

RESULTS

Scores on the BMST, along with group characteristics and demographic information, are presented in Table 1. Further data analysis revealed that there were no significant differences on any variable based on gender. In addition, the 25th, 50th, and 75th percentile scores on the BMST were 58%, 70%, and 84%, respectively.

DISCUSSION

The major objective of this investigation was to assess the basic math skills of entering doctor of pharmacy students prior to their first professional year at a private southeastern school of pharmacy. Previous studies have chosen 70% as a pass level (2). It was felt that doctor of pharmacy candidates should achieve at least a 70% average on an instrument testing eighth-grade level math skills. Surprisingly, the cumulative mean average of the 121 students was 68.90%. Even more disconcerting is the fact that approximately 50% of all the students who took the BMST failed to score 70% or above.

Why did so many students perform so poorly on the BMST? One basic plausible explanation can be offered. The BMST comprised 50 basic

TABLE 1. Demographics, Group Characteristics, and BMST Scores of Students.

Variable	N	Mean	Std. Deviation
Gender			
Males	34		
Females	87		
Age	121	24	4.69
Math/Science Preadmission Grade Point Average (on 4.00 scale)	121	3.07	0.364
PCAT	108	44.91	29.11
Quant. PCAT	108	42.40	26.56
BMST % score	121	68.90	19.89

math items. Students were required to complete the test within a 20-minute time limit (the BMST was validated based on 20 minutes at the eighth-grade level). However, the mean number of "items left blank" on the BMST of this sample was nine. It is plausible that the items left blank were the result of students' inability to answer those items. It is equally plausible that the students did not have enough time to complete the BMST, and the use of calculators would have resulted in more items being answered. However, it was thought that, in addition to the instrument being validated based on a 20-minute limit, the added stress of the time limit might simulate the stress of pharmacists in a practice environment. Sullivan and Clarkson found that nursing students did perform math calculations satisfactorily on paper, but the same students made significant errors when asked to do similar calculations in the clinical setting (13). Haberle assessed the relationship between calculator use and performance in a pharmacy calculations course (10). Students were given an examination in which they were allowed to use calculators. After finishing the test, students were given a ten-minute break and asked to complete a test that was essentially identical to the one just completed (values or numbers to the problems were changed). Students were not allowed to use calculators on the second test. Results revealed that students scored significantly higher and finished in significantly less time on the exam in which calculators were allowed. The author concluded that it is possible that pharmacists might be called on to solve a problem regarding pharmacy calculations without a calculator being available. Also, without an understanding of basic mathematics, pharmacists might inadvertently push the wrong button and not realize that the obtained result cannot possibly be correct (10).

As stated previously, the purpose of assessing the basic math skills of entering doctor of pharmacy students was to identify which students, if any, had basic math deficiencies as early as possible and to offer them an informal program to help improve their skills in this area. The present investigation revealed that many first-year doctor of pharmacy students in the classes of 2003 and 2004 at a private southeastern school of pharmacy may be deficient in basic math skills. The next section describes potential educational interventions the sampled school of pharmacy is considering.

PROPOSED EDUCATIONAL INTERVENTIONS
AND STUDY IMPLICATIONS

Two alternative educational interventions are advanced for remediating those students identified as being deficient in basic mathematics

(those who achieve a percentage score of less than 70). First, those students may voluntarily enroll in a mentor program. The mentor program would be designed to offer students an informal method of improving their skills. The proposed program would be self-paced. Students would purchase a basic math text and workbook recommended by the school of pharmacy, such as *Math Principles & Practice: Preparing for Health Career Success* (14). Students would then work through the exercises at their own pace. The text provides basic math skills for students preparing for health-related careers. The text includes topics such as whole numbers, addition, subtraction, multiplication, division, fractions, and decimals. In addition, students are exposed to such concepts as how to convert decimals to percentages and how to prepare for dosage calculations. The text can be used as a self-study text and employs a common-sense approach, building on basic math skills to facilitate the learning of more complex math calculations (14). Self-tests allow the students to assess their progress and to build confidence in their math computation skills. (Students may meet with their faculty mentor as needed for assistance and guidance.) When the enrolled students master the self-tests, they can retake the BMST.

A second possible intervention would require that math-deficient students purchase a basic math text and workbook recommended by the school of pharmacy (e.g.,14). Then, an informal mini-course covering the nine basic math skills tested on the BMST could be developed by fourth-year doctor of pharmacy candidates doing an education rotation with their school of pharmacy. This would be under the supervision of the faculty preceptor. The fourth-year students on rotation would be required to develop a web-based mini-course with objectives and handouts/slides. In addition, they would be required to administer the lectures, would assign and grade homework/quizzes, and would receive any feedback on their teaching skills from students and the faculty preceptor. Upon competing the exercises, the remediating students would be required to retake the BMST to determine if the deficiencies were resolved.

What are the implications of this study? Two implications can be offered. First, to the extent that basic math skills are prerequisites to success in pharmacy school, the present investigation illuminates a potential problem and identifies a solution for retaining more students throughout pharmacy school. This can have significant financial implications, especially for private schools of pharmacy. For example, total cost for four years of pharmacy school at the sampled school of pharmacy is approximately $68,000. If a student drops out after the first year due to

poor grades resulting from inferior basic math skills, the opportunity cost to the university is $51,000 ($68,000-$17,000).

A second implication of the present study concerns when students enter pharmacy practice. If students with basic math deficiencies make it through the pharmacy curriculum and become pharmacists, they may have a greater propensity for committing medication errors due to poorer basic math skills. The financial and social implications of such a possibility are significant.

The present investigation is subject to at least two limitations. First, the study assessed students from only one school of pharmacy. Although two different classes were involved, it still may be difficult to generalize the results to other schools of pharmacy in different regions of the United States. Therefore, this investigation should be repeated at other schools of pharmacy in different regions of the United States.

A second limitation is that, although the BMST was validated at the eighth-grade level using a 20-minute time limit, the mean number of items left blank was nine. Additional studies are needed at different schools of pharmacy to assess both the number of items left blank and the reasons for the blanks (e.g., do students not have enough time or do they not know the answers).

Future avenues of research could also assess the correlation of success on the BMST and success in math-related courses such as pharmacy calculations, pharmacokinetics, and biostatistics. This may further validate the need for assessing basic math skills and designing appropriate educational interventions. In addition, practicing pharmacists could be tested on the BMST. The results could then be used as a norm group to compare the scores of students with those of practitioners. If practitioners score significantly higher, it may serve as a warning and further validate the need for a basic math skills remediation program.

Despite the aforementioned limitations, the present investigation reports that many first-year pharmacy students may not possess basic math skills. Before final conclusions are drawn concerning the results of this investigation, additional studies are needed at different schools of pharmacy in different parts of the United States.

CONCLUSIONS

There was one major objective of this investigation: to assess the basic math skills of two classes of doctor of pharmacy students at a private

southeastern school of pharmacy. Based on the results, two educational interventions were proposed. These can be offered to students identified as needing remediation in the hope of improving their basic math skills.

REFERENCES

1. Stoklosa MJ, Ansel HC. Pharmaceutical calculations. 10th ed. Baltimore, MD: Williams and Wilkins; 1996:xi-59.

2. Bindler R, Bayne T. Do baccalaureate students possess basic mathematics proficiency? *J Nurs Educ*. 1984; 23:192-7.

3. Edge D. Report of the New Jersey basic skills council. Washington, DC: U.S. Department of HEW, National Institute of Education; December 1979:1-55.

4. Campbell JR, Voelkl KE, Donahue PL. NAEP 1996 trends in academic progress. Washington, DC: National Center for Education Statistics; 1997:49-96.

5. McCann-Flynn JB, Moore JB. Predictors of nursing students' math performance. *West J Nurs Res*. 1990; 12:537-45.

6. Pozehl BJ. Mathematical calculation ability and mathematical anxiety of baccalaureate nursing students. *J Nurs Educ*. 1996; 35:37-9.

7. Dexter P, Applegate M. How to solve a math problem. *J Nurs Educ*. 1981; 20:41-6.

8. Perlstein PH, Callison C, White M, et al. Errors in drug computations during newborn intensive care. *Am J Dis Child*. 1979; 133:376-9.

9. Shockley JS, McGurn WC, Gunning C, Graveley E, Tillotson D. Effects of calculator use on arithmetic and conceptual skills of nursing students. *J Nurs Educ*. 1989; 28:402-5.

10*.* Haberle JE. Does calculator usage add up? *Pharm Times*. 1990; (May):63-6.

11. Pharmacy College Admissions Test technical manual. San Antonio, TX: Psychological Corporation, Harcourt Brace & Co; 1993:1-28.

12. Craig RD. Basic Math Skills Test manual. Salt Spring Island, BC: RD Craig Assessments; 1998:25-8.

13. Sullivan P, Clarkson P. Practical aspects of drug calculations (Report No. 24). Lae: Papua New Guinea University of Technology. ERIC Document Reproduction Service No. ED23163; 1982:1-40.

14. Benjamin-Chung M. Math principles and practice: Preparing for health career success. New Jersey: Prentice Hall Inc.; 1999.