Journal of
INDUSTRIAL
TECHNOLOGY

Volume 15, Number 2 - February 1999 to April 1999

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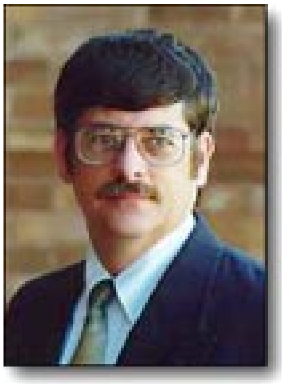
KEYWORD SEARCH

Curriculum
Teaching Methods

Reviewed Article

The Official Electronic Publication of the National Association of Industrial Technology • www.nait.org



A Comparison of the Effectiveness of Applied and Traditional Mathematics Curriculum

By Dr. Stanley L. Lightner

Dr. Stanley L. Lightner is an assistant professor of Industrial Technology at Mississippi State University. He holds an Ed.D. in occupational and adult education from Oklahoma State University. Lightner also taught manufacturing at the secondary and machine tool technology at the vocational-technical levels. Prior to his academic career, he worked in number of manufacturing facilities as a machinist, millwright, toolmaker, and industrial engineer.

Introduction

As philosophical and technological advancements continue to change the workplace, the need for a solid foundation in mathematics for everyone becomes more acute. The simple mathematics skills needed by the workforce of a Tayloristic mass manufacturing facility do not meet the needs of JIT manufacturing and Flexible Manufacturing Systems in today's workplace. Higher mathematics skills are no longer just the domain of the technologists, engineers, and scientists, but are also needed by many of the employees directly involved in daily production. Since technologists are critical members of the teams who plan the future path of manufacturing, they need to understand the limitations which may be placed on the inclusion of technology in the workplace if the mathematics skills of the average employee are not improved. The question then becomes "what type of mathematics curriculum can best prepare people for further mathematics education?" For this research, the decision was made to compare the traditional general mathematics curriculum with the applied mathematics curriculum introduced in the high schools in the past few years.

The purpose of this research was to determine if there was a statistically significant difference in the gain scores of mathematic achievement (dependent variable) between completers of high school General Mathematics and Applied Mathematics 1 (independent variable) as measured by the *Generalizable Mathematics Skills Assessment*. Using contextual learning theory, Hull (1993) and Bottoms, Presson, and Johnson (1992) called for the replacement of General Mathematics by curriculum such as Applied Mathematics 1. However, the review of the literature revealed no empirical research to support this recommendation. Consequently, decision makers have not been able to make data-based mathematics curriculum determinations when choosing between General Mathematics and Applied Mathematics 1. This investigation presents the first available data from a direct comparison of General Mathematics and Applied Mathematics 1 curricula.

Applied Mathematics is a mathematics course that: "focuses on arithmetic operations, problem-solving techniques, estimation of answers, measurement skills, geometry, data handling, simple statistics, and the use of algebraic formulas to solve problems" (Center for Occupational Research and Development, 1992, p. T-1).

General Mathematics is a mathematics course that: "reinforce(s) basic math skills for students who have previously attained them, and extends these skills to further applications and concepts" (Bradby, Levesque, Henke, & Malitz, 1995, p. 142).

Accounts of poor academic skills of students are not new, geographically isolated, nor inconsequential. Numerous reports have challenged the nation to address this problem. According to the Secretary's Commission on Achieving Necessary Skills (SCANS) Report, "we are failing to develop the full academic abilities of most students and utterly failing the majority of poor, disadvantaged, and minority youngsters " (U.S. Department of Labor, 1991, p. vi).

Other publications echoed the theme from the SCANS Report. Writing for the Council for Educational Development and Research, Kober reported "workers can no longer get by with a single, well-practiced assembly line skill and a few reading and computation skills" (1991, p. 1). In an interview regarding educational standards, Kolberg, president of the National Alliance of Business, reiterated United States Secretary of Education Riley's call for strong educational benchmarks. Kolberg's support of the standards was based on a significant number of students "graduating from high school with only a seventh-grade reading level and fifth-grade math skills" (1995, p. 8).

The Department of Education released a report based on the 1992 National Adult Literacy Survey (NALS). This report used the 1985 National Assessment of Educational Progress (NAEP) Young Adult Literacy Assessment definition of quantitative literacy as the capability to locate "relevant quantities embedded in prose text or document, inferring the appropriate operation needed to obtain the result, and performing basic arithmetic operations on the relevant quantities" (Kirsch, Jungeblut, Jenkins, Kolstad, 1993, p. 5). According to this study, 22% of the participants were functioning at or below the lowest level of competence in quantitative literacy. Assuming the sample was representative of United States of America adults, this would translate to 42 million of 191 million adults in this country functioning with minimal mathematics skills. Many of those surveyed were deficient in prose, document, and quantitative skills to the point “that they were unable to respond to much of the survey” (Kirsch, Jungeblut, Jenkins, Kolstad, 1993, p. 18).

The preceding research shows an abundance of people have voiced fears in regard to the socioeconomic impacts resulting from the low academic skills of today’s employees. These studies also recognize the workplace trend, of demanding ever increasing levels of mathematics, communication, and science skills from the employees. Researchers have looked at the present and into the future and see American workers who “are ill-equipped to meet employers’ current needs and ill-prepared for the rapidly approaching high technology, service-oriented future” (National Center on Education and the Economy, 1990, p. 23).

The question then becomes “What can be done about it?” One reaction was based on the popular notion “that mathematics is a largely rule-oriented body of knowledge that is acquired through the memorization of discrete number facts and algorithmic rules” (Merseth, 1993, p. 549). This view of mathematics instruction had helped further “a situation in which students understand intuitively, often correctly, that what they are doing in school today bears little resemblance to what they will be expected to do in the workplace tomorrow” (U.S. Department of Labor, 1991, p. 5).

Concurrently, many schools and state education agencies have reacted with a “more-is-better” approach. This has been fulfilled by increasing the number of mathematics credits required for high school graduation (Merseth, 1993). These and many other attempts to improve mathematics scores had encountered two major problems. The first obstacle lay in the mathematics curriculum. The curriculum was labeled “outdated, repetitious, and unrepresentative of the evolution of the field” (Merseth, 1993, p. 550). Others called the methods employed in today’s high schools best suited for the production of college lecturers. Simultaneously, this method essentially eliminated the majority of students pursuing anything other than “an academically-oriented vocation” (William T. Grant Foundation Commission on Work, Family and Citizenship, 1988a, p. 40). Some of the proponents of curriculum reform proposed the elimination of the general track in secondary education due to a lack of focus and a weakness of rigor in its standards (Hull, 1993). Hull stated “many math . . . educators are recognizing that the ‘applied’ or ‘contextual’ approach is a more effective teaching strategy for middle-quartile high school students” (1993, p. 23). The Southern Regional Education Board (SREB) and its consortium partners also maintained that general mathematics should be eliminated and replaced with applied mathematics (Bottoms, Presson, & Johnson, 1992).

While conducting the literature review for this study, no research was located which directly compared the mathematics achievement between general and applied mathematics students. The studies that addressed Applied Mathematics typically compared Applied Mathematics with Algebra 1. Additionally, these studies tended to focus upon college entrance requirements rather than the mathematics skills needed by those who entered the work force directly from secondary education. In the SREB study cited by Bottoms et al., the mathematics scores compared between the testing sites included the scores from students who had completed courses other than, or in addition to, general mathematics or applied mathematics. Included in this comparison were students who had completed Pre-Algebra, Algebra I, Algebra II, Geometry, and what were called “Higher Level Math” classes. Therefore, due to the inclusion of confounding variables (mathematics classes) no direct comparison could be made between general mathematics and applied mathematics students in the aforementioned study.

Statement of the Problem

There is a lack of data-based research for educators to use for secondary mathematics curriculum decisions when evaluating general and applied mathematics courses.

Research Design

This quasi-experimental study used a two-group design with cluster sampling to investigate the comparison of mathematic skills growth by students in Applied Mathematics 1 and General Mathematics.

The research question that guided the study was:

Are there significant differences in the gains in the total mathematics scores, in the calculation of whole numbers, fractions, decimals, percentages, mixed operations, measurements, or in the estimation of mathematics answers between the students who completed General Mathematics and the students who completed Applied Mathematics 1 as measured by the *Generalizable Mathematics Skills Assessment*?

Methodology

Data for the study were collected using the *Generalizable Mathematics Skills Assessment* developed by James Greenan for the Illinois State Board of Education, Department of Adult, Vocational and Technical Education. The test included sections in the calculation of whole numbers, fractions, decimals, percentages, mixed operations, measurements, and estimation. This instrument was used for both the pretest and posttest. The self selected sample for the study consisted of three rural Oklahoma comprehensive high schools of which two schools participated in both years of the study and one school took part in the first year of the study. This yielded five rounds of testing and 127 sets of pretests and posttests matched by participant. The pretests were administered at the beginning of the school years and the posttests were given at the end of the school years.

Findings

The following tables starting on page 4 present the data developed as a result of the study.

Results of the Study

The results of the study are summarized in the following findings:

1. Applied Mathematics 1 students achieved statistically higher gain scores when compared to the General Mathematics students for the cumulative total and the whole numbers, fractions, decimals, mixed operations, measurement, and estimation sections of the *Generalizable Mathematics Skills Assessment*.
2. There was no significant difference in the gain scores between the Applied Mathematics 1 and General Mathematics students in the percentages section of the instrument.
3. There were significant differences between the pretest and posttest Applied Mathematics 1 students' mean scores for the cumulative total and the decimal and the percentages sections of the instrument.
4. There were no significant differences between the pretest and posttest Applied Mathematics 1 students' mean scores for the whole number, fraction, mixed operations, measurement, and estimation sections of the instrument.
5. There were significant differences between the pretest and posttest General Mathematics students' mean scores for the cumulative total and the decimal, mixed operations, and measurement sections of the instrument.
6. There were no significant differences between the pretest and posttest General Mathematics students' mean scores for the whole numbers, fractions, percentages, and estimation sections of the instrument.
7. The students' final grades in both Applied Mathematics 1 and General Mathematics did not indicate substantial amounts of learning in mathematics took place at either site or in either

Table 1. Summary of Analysis of Covariance of Applied Mathematics 1 and General Mathematics Posttest Scores Using the Pretest Scores as the Covariate

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	p
Dependent Variable: Cumulative Total					
Between Groups	2	15818.84	7909.42	15.79	0.0001*
Within Groups	119	59603.19	500.87		
Total	121	75422.03			
Dependent Variable: Whole Numbers					
Between Groups	2	229.30	114.65	11.52	0.0001*
Within Groups	124	1234.23	9.95		
Total	126	1463.52			
Dependent Variable: Fractions					
Between Groups	2	1578.61	789.30	19.08	0.0001*
Within Groups	119	4923.81	41.38		
Total	121	6502.42			
Dependent Variable: Decimals					
Between Groups	2	15602.09	7801.04	99999.99	0.0001*
Within Groups	124	0.00	0.00		
Total	126	15602.09			
Dependent Variable: Percentages					
Between Groups	2	49.52	24.76	2.18	0.12
Within Groups	124	1409.83	11.37		
Total	126	1459.35			

curriculum.

8. The post-hoc analysis (R^2) of the Analysis of Covariance of Applied Mathematics 1 and General Mathematics gain scores produced large estimates of relative treatment magnitude for the total instrument and the whole numbers, fractions, decimals, mixed operations, and measurement and calculation categories.
9. The post-hoc analysis (R^2) of the Analysis of Covariance of Applied Mathematics 1 and General Mathematics gain scores yielded a medium estimate of relative treatment magnitude for the estimation section.
10. The post-hoc analysis (R^2) of the Analysis of Covariance of Applied Mathematics 1 and General Mathematics gain scores generated a small estimate of relative treatment magnitude for the percent section.
11. The post-hoc analysis (R^2) of the Analysis of Variance of Applied Mathematics 1 pretest and post-test scores yielded a small estimate of relative treatment magnitude for the fractions, decimals, percent, mixed operations, measurement and calculation, and estimation categories and the total instrument.
12. The post-hoc analysis (R^2) of the Analysis of Variance of Applied Mathematics 1 pretest and posttest scores generated a negligible estimate of relative treatment magnitude for the whole numbers category.
13. The post-hoc analysis (R^2) of the Analysis of Variance of General Mathematics pretest and posttest scores generated a medium estimate of relative treatment magnitude in the percent category.
14. The post-hoc analysis (R^2) of the Analysis of Variance of General Mathematics pretest and posttest scores produced a small estimate of relative treatment magnitude for the total instrument and the fractions, decimals, mixed operations, and the measurement and calculation categories.

Table 1 (Continued). Summary of Analysis of Covariance of Applied Mathematics 1 and General Mathematics Posttest Scores Using the Pretest Scores as the Covariate

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	p
Dependent Variable: Mixed Operations					
Between Groups	2	327.28	163.64	14.10	0.0001*
Within Groups	124	1439.18	11.61		
Total	126	1766.46			
Dependent Variable: Measurement					
Between Groups	2	629.70	314.85	13.97	0.0001*
Within Groups	124	2795.30	22.54		
Total	126	3425.00			
Dependent Variable: Estimation					
Between Groups	2	11.24	5.62	5.26	0.006*
Within Groups	124	132.41			
Total	126	143.65			

* = Statistically Significant

Table 2. Summary of Analysis of Variance of Applied Mathematics 1 Pretest and Posttest Scores.

Dependent Variable: Cumulative Total

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	p
Between Groups	1	3148.06	3148.06	5.66	0.02*
Within Groups	125	69526.81	556.21		
Total	1261	72674.86			
Dependent Variable: Whole Numbers					
Between Groups	1	1.53	1.53	0.22	0.64
Within Groups	130	883.65	6.80		
Total	131	885.18			

15. The post-hoc analysis (R^2) of the Analysis of Variance of General Mathematics pretest and posttest scores tendered a negligible estimate of relative treatment magnitude for the whole numbers and estimation categories.

Conclusions

In light of the mixed results from the ANCOVA, the within groups ANOVAs, and the post-hoc analyses, neither of the two mathematics curricula had a noticeable impact upon the student's test scores.

These unexpected findings prohibit sound conclusions about the effect upon mathematics achievement by the students who completed Applied Mathematics 1 and General Mathematics and participated in this study. There was no impact upon the students, neither negative nor positive, based on their test scores. The testing did not effect their grades, graduation, admission to college, or any other area which the students may consider important, this test might have been perceived as a low-stakes test for these students.

An analysis of the final grades of both the Applied Mathematics 1 and the General Mathematics students tends to support the theory that the students involved in this study did not value high mathematics performance. The grades of all of the groups were skewed toward the lower end of the grading scale with very small percentages of students earning an "A, " or a "B." At one site, 65 percent of the students in the Applied Mathematics 1 class earned a "D," or an "F."

In the follow-up survey the instructors were asked if they "noticed any unusual behavior by the students during the post test." There were only two remarks made by the teachers; however, these comments are important. The teacher at site one reported "the students didn't take the test very serious (sic). Many started out doing well, but towards the end of the test time didn't put as much effort into it." A parallel finding came from the instructor at site two. He stated "most of them did not care how they done (sic) on the test therefore most of them did not give complete (sic) effort" (citations withheld to retain anonymity).

Table 2 (Continued). Summary of Analysis of Variance of Applied Mathematics 1 Pretest and Postest Scores.

Dependent Variable: Fractions					
Between Groups	1	42.28	42.28	1.00	0.32
Within Groups	125	5272.65	42.18		
Total	126	5314.93			
Dependent Variable: Decimals					
Between Groups	1	682.67	682.67	5.24	0.02*
Within Groups	130	16928.05	130.21		
Total	131	17610.73			
Dependent Variable: Percentages					
Between Groups	1	138.02	138.02	12.17	0.0007*
Within Groups	130	1474.89	11.34		
Total	131	1612.91			
Dependent Variable: Mixed Operations					
Between Groups	1	17.21	17.21	1.06	0.30
Within Groups	130	2113.67	16.26		
Total	131	2130.88			
Dependent Variable: Measurement					
Between Groups	1	33.55	33.55	1.08	0.30
Within Groups	130	4026.33	30.97		
Total	131	4059.88			
Dependent Variable: Estimation					
Between Groups	1	0.06	0.06	0.04	0.84
Within Groups	130	189.66	1.46		
Total	131	189.72			

* = Statistically Significant

There have been similar results associated with the National Assessment of Educational Progress (NAEP). Shanker (1990, p. E-7) reported that "if students know that what they do on a test doesn't matter, they may decide it's not worth their while to put forth any effort."

According to Burke (1991) student apathy toward the NAEP examination was high. He quoted a teacher who observed students randomly marking their answer sheets. When the teacher inquired into the students' behavior the response was "why bother" (p. 5). Kiplinger and Linn (1993) have arrived at a parallel conclusion for low stakes tests such as the NAEP.

Based on the findings, this researcher derived the following conclusions:

1. With the available data, no determination can be made as to which mathematics curriculum, Applied or General, is more effective.
2. Due to the statistically equivalent or superior scores by the Applied Mathematics 1 students, Applied Mathematics 1 may be substituted for General Mathematics without a loss of learning.

Implications

In the course of the investigation this researcher was informed by a number of state and local education agencies of the replacement of General Mathematics by Applied Mathematics 1. While there were many individuals who believed this is an educationally sound decision, this research should be viewed as a preliminary study to determine if there is empirical evidence to support a change from General Mathematics to Applied Mathematics 1. The replication of this study in different locations of the country is needed to help determine which mathematics curriculum can best serve the needs of the students and the community, including the manufacturing community.

The educational community needs to continue to develop procedural standards for the evaluation and replacement of theory-based curricula with contextual-based curricula. Until

Table 3. Summary of Analysis of Variance of General Mathematics Pretest and Posttest Scores.

Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	p
Dependent Variable: Cumulative Total					
Between Groups	1	3242.92	3242.92	6.10	0.015*
Within Groups	142	75503.08	531.71		
Total	143	787446.00			
Dependent Variable: Whole Numbers					
Between Groups	1	7.12	7.12	0.52	0.47
Within Groups	144	1982.00	13.76		
Total	145	1989.12			
Dependent Variable: Fractions					
Between Groups	1	79.27	79.27	1.38	0.24
Within Groups	142	8145.62	57.36		
Total	143	8224.89			
Dependent Variable: Decimals					
Between Groups	1	1047.27	1047.27	7.48	0.007*
Within Groups	144	20167.67	140.05		
Total	145	21214.94			
Dependent Variable: Percentages					
Between Groups	1	25.10	25.10	2.62	0.11
Within Groups	144	1380.13	9.59		
Total	145	1405.24			

this step is taken, educators will continue to be accused of a "flavor-of-the-month" mentality toward curriculum reform.

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Table 3 (Continued). Summary of Analysis of Variance of General Mathematics Pretest and Posttest Scores.

Dependent Variable: Mixed Operations					
Between Groups	1	38.73	38.73	4.12	0.04*
Within Groups	144	1353.49	9.40		
Total	145	1392.22			
Dependent Variable: Measurement					
Between Groups	1	157.07	157.07	7.50	0.007*
Within Groups	144	3015.81	20.94		
Total	145	3172.88			
Dependent Variable: Estimation					
Between Groups	1	2.16	2.16	2.51	0.11
Within Groups	144	124.27	0.86		
Total	145	126.44			

* = Statistically Significant

Table 4. Percentages of Student Final Grades by Curriculum and Site

		% of Final Grades				
Curriculum	Site	A	B	C	D	F
Applied Mathematics 1	1	0	5	30	25	40
Applied Mathematics 1	2	0	23	51	26	0
General Mathematics	1	4	4	28	28	36
General Mathematics	2	6	12	53	18	12

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Table 5. Post-Hoc Analysis of the Analysis of Covariance of Applied Mathematics 1 and General Mathematics Gain Scores

Category	R^2	Size of Effect
Whole Numbers	0.16	Large
Fractions	0.24	Large
Decimals	1.00	Large
Percent	0.03	Small
Mixed Operations	0.18	Large
Measurement and Calculation	0.18	Large
Estimation	0.08	Medium
Total Score	0.21	Large

Table 6. Post-Hoc Analysis of the Analysis of Variance of Applied Mathematics 1 Pretest and Posttest Scores

Category	R^2	Size of Effect
Whole Numbers	0.00	Negligible
Fractions	0.01	Small
Decimals	0.05	Small
Percent	0.02	Small
Mixed Operations	0.03	Small
Measurement and Calculation	0.05	Small
Estimation	0.02	Small
Total Score	0.04	Small

Table 7. Post-Hoc Analysis of the Analysis of Variance of General Mathematics Pretest and Posttest Scores

Category	R^2	Size of Effect
Whole Numbers	0.00	Negligible
Fractions	0.01	Small
Decimals	0.04	Small
Percent	0.08	Medium
Mixed Operations	0.01	Small
Measurement and Calculation	0.01	Small
Estimation	0.00	Negligible
Total Score	0.04	Small