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The Relationship Between Mathematics and Communicative Skills as Shown by Classes in Functional Mathematics at Savannah State College During 1954-55

By Sylvia E. Bowen

Introduction

The major purpose of this study was to determine the relationship, if any, between mathematics and the communicative skills (English). Hence, it seemed advisable to establish whether or not effective language usage helps to clarify mathematical concepts and processes, and **vice versa.**

This study was motivated by many factors. One factor was an effort to do something specific in carrying out one of the major objectives of the College-Improving Communicative Skills. Another motivating factors was the emphasis which is now placed upon mathematics in General Education. The investigator felt that the functional aspects of mathematics could be seen more clearly if students were made aware of mathematics as a means of communicating and clarifying ideas. The investigator supports the hypothesis that mathematics may be developed as a way of thinking. "Actually, there are two basic languages: (a) one's mother tongue, and (b) mathematics."[1]

The investigator's teaching experience reveals that students not only fail to tie up mathematics and common sense but also fail to appreciate mathematics as a practical tool in understanding many ideas which are characteristically non-mathematical. Students need to become articulate in mathematics in order to communicate the concepts they have formulated. There is a need for dispelling some of the basic fears of students with regard to mathematics. These fears are often the result of language difficulties for "mathematical difficulties are often language difficulties."[2]

The investigator was searching for tangible ways of correlating mathematics with the communicative skills and

[1]G. R. Seidal, "Mathematics—A Language", *The Mathematics Teacher*, XLVIII, No. 4 (April 1955) p. 215.

[2]H. C. Trimble, L. C. Peck, and F. C. Bolser, *Basic Mathematics for General Education*, Second Edition, (New York, 1955) p. 321.

organizing a course which would include "material that will enrich the students' general college experience".[3]

Mathematics is an area which draws so heavily upon other subject matter areas and contributes in turn so much to these same or other subject matter areas that it is inconceivable to isolate it as a subject in itself. These subject matter areas and mathematics and interdependent upon each other and frequently use the same descriptive language. Essentially "being literate in America today means knowing both quantitative language (English) and quantitative language (mathematics)."[4]

In this study no attempt is made to include the whole freshman class of 1954-55. Out of an average enrollment of 474 freshmen,[5] the investigator taught only a total of 149 students. Of these 149 students only 85 students actively participated in the study. This choice was made because the investigator was teaching all the Functional Mathematics classes at the time the study was begun. This fact reduced variations in procedures and minimized variations in personnel. This study covers only the classes in Functional Mathematics during the Spring Quarter of 1955. It was impossible to make an exhaustive list of words or to include all interesting and relevant themes. It was impractical to define more words inasmuch as tedium would have resulted, and space did not permit such treatment.

All students contributed to the collecting and treating of the data. A word list of 150 words was compiled. Written definitions of each word were recorded. The definitions were mathematical, but the words were analyzed, explored, and developed to see in how many different ways they may have been used. All words were outgrowths of class discussions, explanations and demonstrations. The definitions were studied and reproduced on examinations and in themes written by the students. The word list was alphabetically reorganized. It contained 150 words. Twenty words (13⅓% or 13.33%) were selected for their mathematical connotations. Seven students' papers were chosen to illustrate how mathematical terms are successfully and picturesquely incorporated into written coherent themes. A part of the study demonstrates how the investigator used effective language to clarify mathematical concepts.

Findings

The findings of the study are presented under three major headings:

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[3]E. C. Clark, *College Mathematics,* (New York, 1950) Preface iii.

[4]H. C. Trimble, L. C. Peak, and F. C. Bolser, *Op. Cit.*, p. 5.

[5]Courtesy of the Registrar's Office, Savannah State College, Savannah, Georgia.

A. Mathematical definitions of words frequently used in our vernacular tongue.

B. Mathematical terms used in written assignments.

C. Mathematical terms used in discussion techniques.

A. Mathematical Definitions

"Words are the leaves of the tree of language, of which, if some fall away, a new succession takes their place."—French[6] This part of the study is devoted to words which the investigator selected for definitions and which are expressly designed to improve the students' vocabularies.

Approximate—An approximate number is a number obtained by measuring. Since measurements are liable to errors even though these errors may be very small, the nature of approximation is ineritable. Measurements, too, depend largely upon the measuring instrument used, its preciseness and accuracy. The accuracy of the instrument used depends on the use which is to be made of the measurement. But a number obtained by measurement can, at best, be only approximate.

Average—An average is defined mathematically as a single representative size or measurement. It is used to indentify either an arithmetical mean, a median or a mode or to identify them simultaneously. The term is used loosely to represent what is considered mathematically as an arithmetical mean. Average may be defined also as a sum or quantity which is the middle one among a number of different sums or quantities.

Base—A base is a number which necessarily involves an exponent. It is a part of an exponential expression. It is a number which is to be used as a factor as many times as the exponent indicates. It is a number related to the formation of our number system. Our number system is synthetically related to the base ten. In the expression 5^3, the base is five and the exponent is three. The exponent indicates that the base "5" is to be used as a factor as many times as the exponent "3" indicates. The value of 5^3 is 5x5x5 or 125. A general expression like a^n (read a to n^{th} power) indicates that the "a" is to be used as a factor "n" times and that "n" may take on any assigned or specified value.

A number like 12 is synthetically composed of one ten and two ones or $1(10) + 2(1)$ or $1(10) + 2(10)^0$ where a zero used as an exponent automatically makes the value of the entire parenthesis equal to one.[7] A number like 347

[6]As quoted in: *The New Dictionary of Thoughts* compiled by Tyron Edwards (New York, 1954) p. 324.

[7]The ( ) indicates multiplication. The expression is read "one times ten plus two times one or one times ten plus two times ten to the zero power.

builds up aw $3(10)^2 + 4(10) + 7(1)$. A number like .653 may be expressed as $\frac{653}{1000}$ or $6(10)^2 + 5(10) + 3(1)$ times $(10)^{-3}$. Any denominator may be expressed as a power of ten by a proper synthetic process and the use of a negative exponent. The term base is also an integral part of our logarithmic numbers. In the expression or equation $X^4 = 16$, "4" is the logarithm of "16" to the base "X" or the expression may be written logarithmically as $\log_x 16 = 4$.

Cancel—To cancel means to remove (a common divisor) as from numerator and denominator or to remove (equivalents) on opposite sides of an equation.

Cardinal—A cardinal number is a type of number used in our number system. It simply names the numerical symbols as 3, 4, 5, 9. Cardinal numbers are used in counting or in answer to the question "How many?" They give no information about the kind of things counted, or about any relation they may have to each other. Ordinal numbers name the sequence or order as second, ninth, twentieth, the third month, the seventh day.

Check—The term check is used primarily to ascertain the correctness of the solution to an equation. An identify on both sides of the equation is established if the solution is correct. To solve the equation: $3x + 5 = 5x - 9$, the procedure is as follows:

(Adding and subtracting equals)

(Dividing equals by equals)

$$\begin{aligned} 3x + 5 &= 5x - 9 \\ 3x - 5x &= -9 - 5 \\ -2x &= -14 \\ x &= 7 \end{aligned}$$

To check the equation the value "7" is imposed upon "X" by a direction substitution:

$$\begin{aligned} 3x + 5 &= 5x - 9 \\ 3(7) + 5 &= 5(7) - 9 \\ 21 + 5 &= 35 - 9 \\ 26 &= 26 \end{aligned}$$

Complex—The term complex is used to describe the type of fraction which has a fraction or a mixed number in the numerator or in the denominator or in each. It is used also to describe a number and an imaginary number. In the complex number $a + bi$, "a" is the real number and "bi" is the imaginary number procided "b" is not equal to zero.

Degree—The degree of an expression is the rank or order of an expression where "expression" is interpreted as a polynomial or an equation or a monomial. The equation $x^2 + x - 2 = 0$ is an equation of the second degree. The largest numerical exponent names the degree of an equation or of a polynomial. The monomial $x^3 y^2 z$ is an expression of degree 6 where the exponents 3, 2, and 1 are added to obtain the degree of the expression. A degree is also defined as the 360th part of a revolution or of the circumference of a circle. It is the basic unit of the sexagesimal system of measurement of angles.

Exact—An exact number is a number obtained by counting in contradistinction to the preceding definition of an approximate number. An exact number is a discrete measurement where measurement implies counting. The number 1243 is an 1240 or as, 200 the latter numbers would be approximate numbers.

Exact describes, also, the kind of interest which is computed on the basis of a 365-day year.

Function—This word defines a quantity so related to another quantity that any change in the value of one is associated with a corresponding change in the value of the other. The area of a rectangle is a function of both its width and its length. If the length remains the same and the width changes then the area will change; and if the width remain the same and the length changes then the area will change. Conversely, if the area changes and either one of the dimensions remains the same, then the other dimension must also change.

Index—An index number is a number understood or written within the depressed part of a radical sign to indicate what root of the number is to be obtained. The cube root of twenty-seven is written symbolically as $\sqrt[3]{27}$. "3" is the index of the radical. $\sqrt[3]{27}$ may be written also as 27⅓ where the index is expressed as the fraction ⅓. Any index may be expressed as a fractional exponent. The number or index two is understood in the case of the square root so that no index number is written.

Interest—Interest is money paid for the use of money. Simple interest is interest computed on the Principal only. Compound interest is interest computed on the principal plus accrued interest for a specified period. Simple interest may be exact or ordinary. Exact simple interest uses a 365-day year. Ordinary simple interest uses a 360-day year. Compound interest is computed from a table which is based on a 360-day year. Everyday experiences with interest are in relation to a 360-day year.

Prime—A prime number is a number which has no other factors except itself and the number one. A prime number is a number which is divisible by no other numbers except itself and the number one. Prime numbers are numbers like 2, 3, 5, 7, 11, 17, 23.

The prime factors of a number are all the smallest numerical integral divisions of the number. The prime factors of 36 are 2, 2, 3, 3; of 98 are 2, 7, 7; of 48 are 2, 2, 2, 2, 3.

By using prime factors in the correct way it is possible to obtain a least common divisor of a set of numbers with infallibility.

Progression—A progression is a series or set of numbers which are related to each other by a uniform law. A progression may conform to a law which defines it as an arithmetical progression or to a law which defines it as a geometrical progression. An arithmetical progression. An arithmetical progression is identified by a constant addition of either a positive or a negative number. The elements progress by a constant difference. The numbers 4, 6, 8, 10 constitute the pattern of an arithmetical progression where the constant difference is a positive two. The numbers 11, 7, 3, —1 constitute an arithmetical pattern where the constant difference is a negative four. A geometrical progression is identified by a constant ratio governing the behavior pattern of the numbers. The elements of a geometrical progression progress by a constant factor. The ratio of any two adjacent elements is constant. The numbers 4, 8, 16, 32 constitute the pattern of a geometrical progression because the ratio of 4 to 8 is the same as the ratio of 8 to 16 is the same as the ratio of 16 to 32. The constant ratio or factor is one-half or two. Each preceding number is multiplied by two to obtain the next number.

In either type of progression at least three numbers must be given in order to determine the pattern used and thus identify the type of progression which these numbers form.

Proportion—A proportion is an equation stating that two or more ratios are equal. It is an equality of ratios. The ratio of a to be equals the ratio of c to d is set up in equation form as $\frac{a}{b} = \frac{c}{d}$. This equation may be stated as the proportion: a:b::c:d. Where three ratios are set equal to each other only two may be used at a time to form a true proportion. The ratio $\frac{a}{\text{Sin A}} = \frac{b}{\text{Sin B}} \quad \frac{c}{\text{Sin C}}$ may bet set up in three proportions: a:SinA: :b:SinB; a:SinA: :c :SinC; B:SinB: :c :SinC. Given any three quantities in a proportion the fourth quantity may be found by the rule: The product of the means (the second and third terms) equals the product of the extremes (the first and fourth terms). To solve a proportion which is set up as the equality of two ratios, multiply the numerator of the first ratio by the denominator of the second ratio and set this product equal to the product of the denominator of the first and the numerator of the second ratio. The symbolic representation is as follows:

a : b :: c:d is expressed bc = ac

$\frac{a}{b} = \frac{c}{d}$ is expressed ad = bc.

Either equation may be solved for any one of the four quantities if the other three quantities are given. If: a = 4, b = 5, c = 6 then: 4:5: :6:d or $\frac{4}{5} = \frac{6}{d}$ and 4d = 30 and d = 7½. Two numbers alone cannot form a proportion; they can only form a ratio.

A set of variable quantities may be directly or inversely proportional to each other.

Radical—A radical is a symbol used in mathematics derived from the Latin word radix which means root, and is probably an exaggerated form of the initial letter of this word (r). This symbol $\sqrt{}$ is a radical.

Root—A root of a number is a quantity which when multiplied by itself a certain number of times (indicated by an index) produces another quantity. The third root or cube root of sixty-four is four. In symbols it is written $\sqrt[3]{64} = 4$. This means that 4 times 4 equals 64. An even root of a positive number may be either positive or negative. The square root of 25 is either +5 or —5. A root is also the solution to a conditional equation. It is a value which satisfies an equation. In the equation: 3d = 15, "d" must equal "5" in order to satisfy the equation. "5" is then a root of the equation.

Sign—A sign is a character indicating the relationship between quantities or an operation performed on them. The four fundamental operations of addition, subtraction, multiplication and division are devoted by the signs +, —, ×, ÷. A sign of "=" or "—" where no operation is involved is a sign of quality and is read positive or negative. Thus "+4" and "—6" are read a positive four and a negative six instead of plus four and minus six. Signed numbers devote oppositeness in quality. The absolute value of a number is the numerical value of the number disregarding the sign.

Significant—The word significant is defined here in its association with digits. The significant digits in a number are all the non-zero digits in the number except where zero fall between non-zero digits in which case the zero is also significant. Significant digits are important when calculations are made with approximate numbers because an answer is only as accurate as the least accurate of the numbers involved in the calculation. The numbers 34.306, 34000, and .0329 have 5, 2 and 3 significant digits respectively. If decimals numbers are used, the least accurate number is the number having the fewest number of places following the decimal point. Since the answer can be no more accurate than the least accurate of the numbers used in the calculation, the number of significant digits in the least accurate number determines how many significant digits should be retained in the answer. In the calculation 4.1 times 3.416, 4.1 is the least accurate of the numbers, and contains two significant digits, therefore the final calculation should contain two significant digits. 4.1 times 3.416 equals 14.186; 14.186 times 2.416 equals 34.273376. The final answer should be simply 34 (two significant digits). "The number of significant digits in a product or quotient is no greater than the smallest number of significant digits in any one of the measures used in the calculation.—You should round off the answers you get (by multiplying and dividing approximate numbers) to the number of significant digits of the measure that has the least number of significant digits."[8]

Variable—A variable is a quantity that may assume a succession of values. It is a symbol representing any one of a class of things. It is a literal number (letter) that may take on different numerical values in the course of a discussion. "A variable is a symbol which represents a number that may vary within a given range."[9]

B. Mathematical Terms Used In Written Assignments[11]

"In this day when communication plays such a prominent part in our lives, not only do English teachers have an obligation to help youth to develop ability in writing and speaking, but the teachers of other subjects, for in all classes opportunities present themselves scores of times each day for effective writing and oral communication."[10]

The investigator herewith presents the partial results of taking advantage of some of these "opportunities":

> Making a dress requires a **number** of **significant operations.** The **illustrated** guide sheet must be followed **accurately.** The **symbols** on the pattern must be **checked.**
>
> The Federal Bureau of Investigation found a case **similar** to one they had on file.

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[8]H. C. Trimble, L. C. Peck and F. C. Bolser—*op. cit.*, p. 111.

[9]Paul K. Rees, Fred W. Sparks—*College Algebra*—p. 73.

[10]Berenice Beggs, "They Learn To Write by Writing." *The English Journal*, XLIV, No. 5 (May 1955) p. 293.

[11]The underscored words are words which appeared in the word list kept by the students.

The **identity** of the person was not revealed. They wondered whether their **functions** were **proper** or **improper.** The Bureau decided to **cancel** the case.

Leadership is an important human **quality.** It is based upon **principles** and **facts** pertinent to science. Leadership is a science of **positive** and **negative** emotions. Good leaders must **demonstrate** their **capacity** to lead. Persons of **average** capacity may become **principal** leaders.

The value of a good education is difficult to **describe.** The **whole** outlook of a person may be changed in **proportion** to the **degree** of education he acquires. Educated people usually **amount** to something and get the greatest **advantages** out of life.

Music consists of rhythm, harmony and melody. The **time** is written in **fractions.** The **numerator** tells how many counts a **measure** receives, and the **denominator** tells what **type** of note gets one count. A dot adds **half** the **value** of the note by which it is written. Music has **symbols** and **volume.** The theory of music is **significant** to those who have an **interest** in music. Music may be **transposed** for different effects.

My **budget account** allows me to **approximate** my weekly spendings. I can buy a dress which shows **signs** of **quality** on the **installment** plan. The prime **factor** to be considered is the **logic** of the **investment. Quantity** is not a **basic** factor in spending.

The automobile is a very **precise** machine. The **unit** of **power** is the internal combustion engine in which the **measurements** must be very exact. The **average** automobile engine has four to six **cylindrical** holes. The power **capacity** of the engine is **relative** to the **diameter** and **volume** of the **cylinder,** and to the compression **ratio** in each cylinder. The **accuracy** of the speedometer is a **factor** in **checking rate** of travel and the **time** to be used in going a **given distance.** The automobile is an **index** of **progress.**

C. Discussion Techniques

"It is becoming increasingly difficult to read so much as ten sentences without encountering a word which has quantitative connolations. . . . If our culture is to keep pace with the technological advances of its time, a clear understanding of mathematical concepts is going to have to be incorporated into the language arts."[12] Hence, the investigator presents a setting in which effective language was used to clarify mathematical concepts and assist in **precise, exact,** analytical thinking. In treating the subject of Percentage the investigator discovered that difficulties arose in discriminating between the concepts of **per cent** and percentages. The language chosen described Percentage as something which **denotes** a part as the part is **related** to the whole. Per cent was described as something which denoted a **ratio** of a part with reference to one hundred. Percentage is **concrete** and **tangible.** Per cent is **abstract.** In defining 20 words out of 150 words, "20" is the part and therefore represents percentage. The **ratio** of 20 to 150 will give a per cent when the unknown per cent is set up in ratio to 100. If X represents the per cent, the: $\frac{20}{150} = \frac{X}{100}$ or 20 :150 :: X : 100 or 150X = 2000 and X equals 2000 **divided** by 150 which gives a **quotient** correct to two **decimal** places of 13.33. These 20 words are 13.33% of 150 words.

Confusion existed also between the terms Base, Rate and Percentage. By pointing out that the **Base** is always the **whole** and that the **operation** of **multiplication** is always used to **find** the **Percentage,** and that the operation of **division** is always used to find the **Base** or the **Rate,** and that **Percentage** is always in the **numerator** or is always the **dividend,** the whole **process** of finding either B, P, or R was **definitely simplified** and **clarified.** The use of the **formula** BR=P was no longer a problem. The additional note that **B** always follows the preposition "of" in worded problems was significant in helping to **identity** P and R.

Another confusion showed up in the concepts of "odd" and "even." "Even" was incorrectly conceived as any **exact division:** "As seven goes into forty-nine an even **number** of times. "Even" was illustrated to **denote exact divisibility** by two "Odd" was readily understood as the **ulternate** of **even.**

Educational Implications

The findings of this study reveal that mathematics is **pertinent** to understanding the language involved in our daily usage. Functional competence in mathematics is an aspect of functional competence in expressing ideas clearly and precisely. The investigator supports the hypothesis that

[12]Agnes Dodds, "The Language and Arithmetical Requisites of Clear Thinking." *The Teacher College Journal,* XXVI, No. 5 (March 1955) p. 84.

mathematics and the communicative skills are intrinsically related and mutually interdependent.

> The study of mathematics cultivated the reason; that of the languages, at the same time, the reason and the taste. The former gives grasp and power to the mind; the latter both power and flexibility. The former, by itself, would prepare us for a state of certainties, which nowhere exists; the latter for a state of probabilities, which is that of common life. Each by itself does but an imperfect work: in the union of both, is the best discipline for the mind, and the best mental training for the world as it is—Lyron Edwards.[13]

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[13]As quoted in *The New Dictionary of Thoughts*—op. cit., p. 380.