A Triangulation Theme

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Abstract

Students often find it extremely difficult to memorise a host of formulae and more importantly to use them in context when required. By identifying a wide variety of different three variable formulae and commenting on their uses, this article seeks to reinforce basic scientific principles and simultaneously make connections using real life, everyday situations. The paper followed numerous cohorts of students from different countries in several continents over a 45-year period. The triangulation theme is emphasised and derivations from sample fundamental equations are discussed. Results showed that apart from bringing together commonalities, the dangers of compartmentalisation are minimised. This article also serves to encourage thinking outside the box. By requesting that three variable relationships be identified in as many subject areas as possible, the reader is forced to bring together ideas from different subjects, thereby undermining the tendency to compartmentalise. It is hoped that readers will become more sensitive to the threesome nature of basic scientific laws that govern the universe and find science much more engaging and exciting. Educators might consider paying specific attention to the triangulation pattern in relationships in order to improve teaching practices and enhance learning.

Keywords: equations, formulae, triangulation, variables, scientific laws.

Introduction

Solution of simple equations especially in the sciences poses a serious problem to many students. The idea of transposition, while useful in many instances has plagued many a student when intricate operations like squares, square roots, cubes, cube roots, etc. become a part of the equation. While in simple straightforward situations transformation appears to be the easy way out, it creates a dilemma to students when faced with more complex equations involving several different operations.

This author is proposing that instead of teaching transposition, an equation should be treated as a balance in which whatever operation is performed on the right hand side of the equation the identical operation must be performed on the left hand side of the equation if balance is to be maintained. Anything short of identical operations on each side will result in an imbalance and the equation will no longer hold true. An inequality results.

The triangulation theme emphasises the threesome nature of relationships that may be easily visualised in a triangle where the topmost variable appearing in the triangle represents one side of the equation and the other two variables at the bottom of the triangle represent the other side of the equation. By visualising this simple threesome arrangement enclosed in a triangle the student is better able to remember the equation for future use.

Literature Review

The term triangulation is often used in social science research to denote two or more methods used for checking results of the study on a particular subject. Triangulation is frequently used in navigation and land surveying to ascertain a single point. Essentially, the idea is that several methods are more likely to provide accurate results as opposed to a single method used, thereby increasing reliability, validity and most importantly credibility. Altrichter et al. (2008) contended that triangulation ‘gives a more detailed and balanced picture of the situation.’

Cohen and Manion (2000) defined triangulation as an ‘attempt to map out, or explain more fully, the richness and complexity of human behavior by studying it from more than one standpoint.’ This viewpoint was also shared by O’Donoghue and Punch (2003) who referred to triangulation is a ‘method of cross-checking data from multiple sources to search for regularities in the research data.’

In this article the triangulation theme is referred to three variables that are related to each other in a specific manner, determined by the results of much experimentation by qualified researchers. Any one variable may be easily expressed in terms of the other two by employing the basic principle that whatever operation is performed on the right hand side of the equation the identical operation must be performed on the left hand side of the equation if balance is to be maintained.

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Compartmentalisation or placing information so strictly in separate compartments that the brain can only function separately and not holistically as the universe demonstrates is a common problem especially among young students. Their idea is to keep certain facts and ways of reasoning as belonging to a particular subject area, to the extent that such facts are not transferable to other subject areas.

Apart from bringing together commonalities this article serves to underscore the dangers of compartmentalisation and seeks to encourage thinking outside the box. By requesting that three variable relationships be identified in as many subject areas as possible the reader is forced to bring together ideas from different subjects, thereby undermining the tendency to compartmentalise.

Methodology

Numerous cohorts of students from different countries in several continents over a 45-year period were closely followed to determine how well they were able to recall and use a number of scientific formulae containing three variables. Notebooks, examination papers, homework assignments among other pertinent documents like log sheets, diaries, etc. were examined closely. Student cohorts came from a number of different levels (Form 1 to Forms 6 of high schools and Year 1 to Year 3 of college) from a variety of educational institutions.

Results

Using an example of a three variable relationship, Figure 1 illustrates the basic principle of a triangle in which three variables are enclosed. The uppermost variable lies on one side of the equation and the product of the two variables at the bottom of the triangle lies on the other side of the equation. Using the figure below, the resulting equation will be **V= IR**.

The Triangle

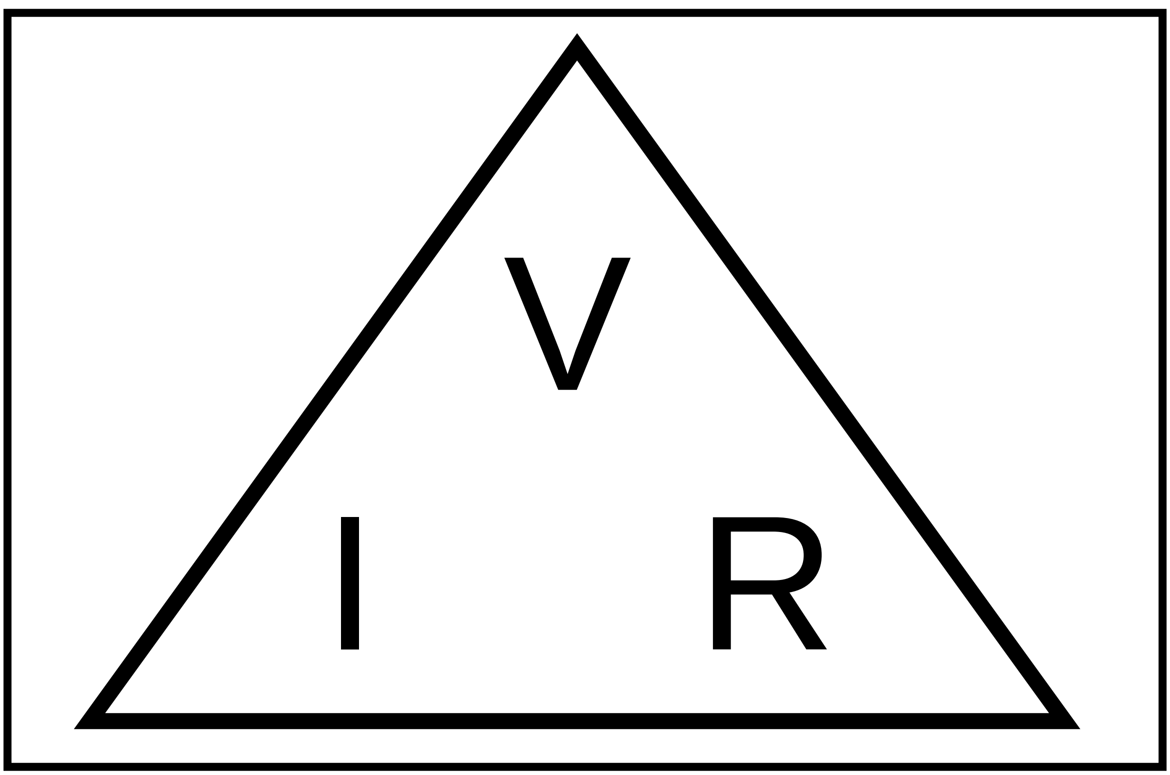

Figure 1 The V I R Relationship

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The foregoing figure illustrates the basic principle of a triangle in which three variables are enclosed. The uppermost variable lies on one side of the equation and the product of the two variables at the bottom lies on the other side of the equation. Using the foregoing figure, the resulting equation will be:

$$V = I\,R$$

Where V = Voltage in the units Volts

I = Current in the units Amperes

R = Resistance in the units Ohms

Here's another student example:

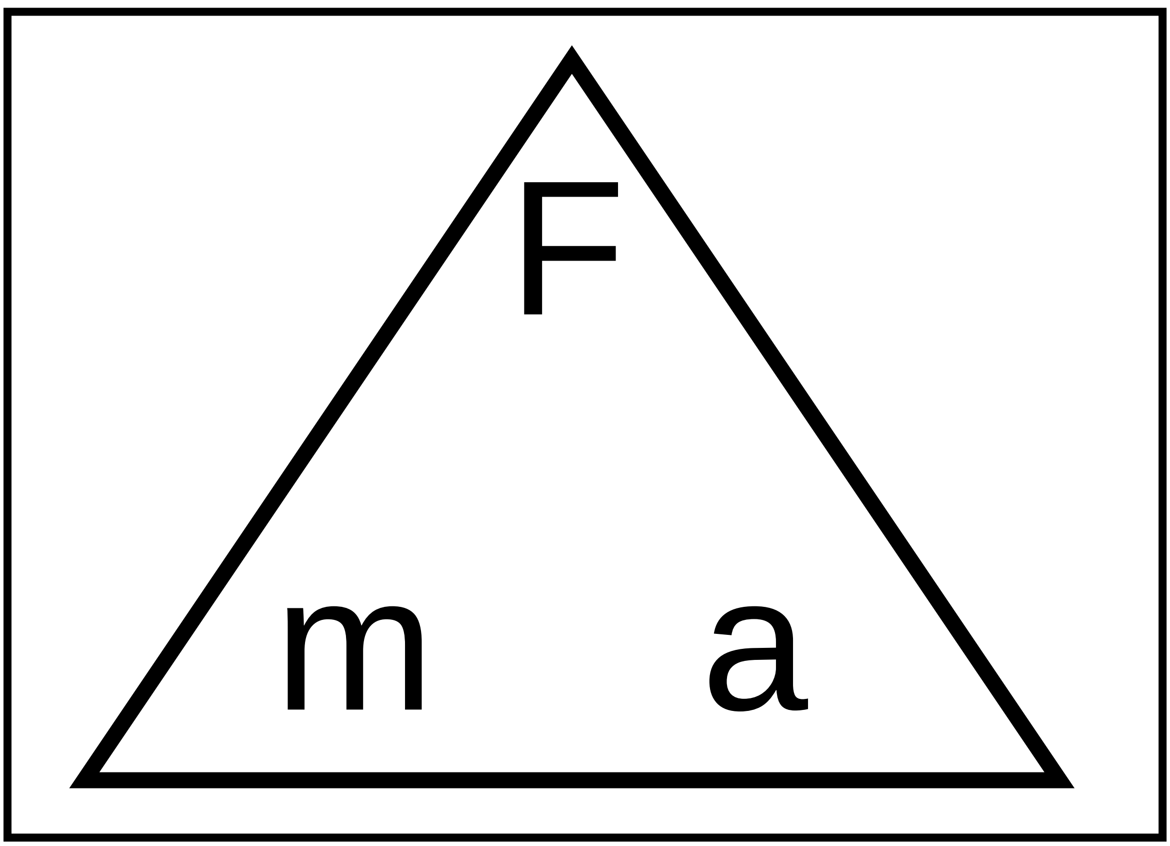

Figure 2 The Fma relationship

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The foregoing figure illustrates the equation:

$$F = ma$$

Where F = Force in the units Newtons

m = Mass in the units Kilograms

a = Acceleration in the units ms^{-2}

Working with the equations

As explained earlier, an equation is like a balance. Whatever operation is performed on the right hand side of the equation the identical operation must be performed on the left hand side of the equation if balance is to be maintained. Anything short of identical operations on each side will result in an imbalance and the equation will no longer hold true. An inequality results.

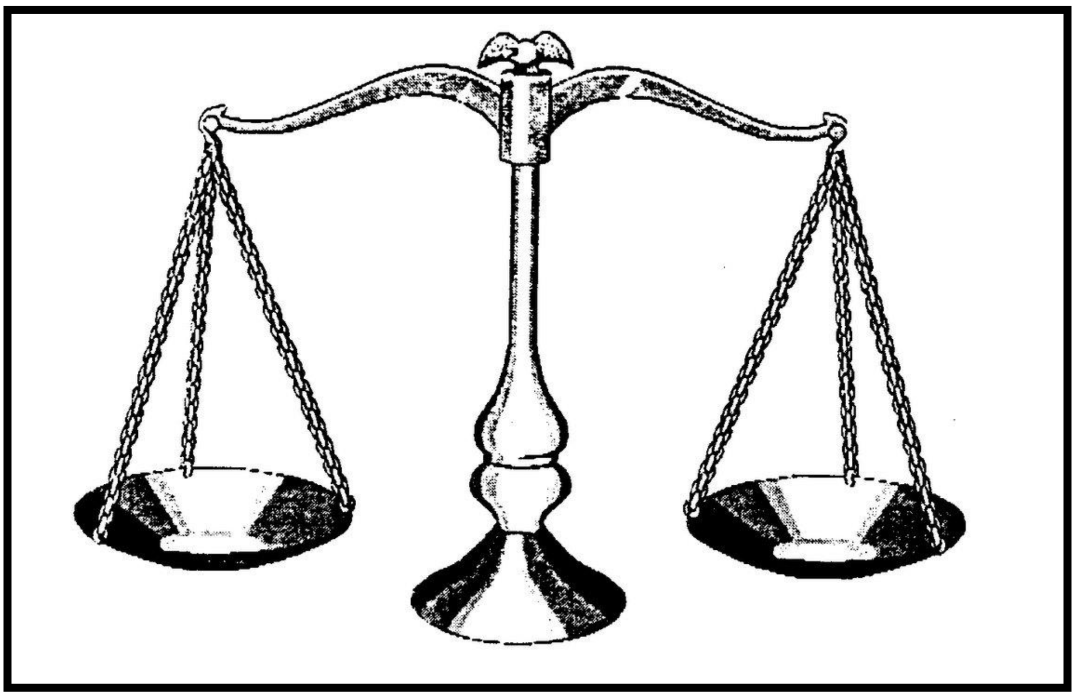

Figure 3 A simple balance

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As an example using V = IR, we can divide both sides of the equation by I, giving us V/I = R. Similarly, using the same equation V = IR, dividing both sides of the equation by R we have V/R = I.

In this way any one of the three variables may be expressed in terms of the other two variables as shown:

V = IR
R = V/I
I = V/R
Where V = Voltage in the units Volts
I = Current in the units Amperes
R = Resistance in the units Ohms

At a glance the principle seems obvious and straightforward. What then are some implications of this?

Derivation of Units

So often students cannot determine the units of certain variables. The equation principle may also be effectively used to determine the unknown units of various variables.

For example, if the units for Voltage is Volts; the units for Current is Amperes and the units for Resistance is Ohms, then it may be inferred that:

- 1 Volt is the voltage when 1 Ampere of current flows through a resistance of 1 Ohm.
- A voltage of 1 Volt allowing a current of 1 Ampere to flow through it suggests that the resistance will be 1 Ohm.

- A voltage of 1 Volt using a resistor of 1 Ohm will allow a current of 1 Ampere to flow through.

Similarly,

$$F = ma$$
$$m = F/a$$
$$a = F/m$$

Where F = Force in the units Newtons
m = Mass in the units Kilograms
a = Acceleration in the units ms^{-2}

Using the second formula F = ma, where F = Force in the units Newtons; m = Mass in the units Kilograms; a = Acceleration in the units ms^{-2} it may be inferred that:

- 1 Newton is the Force when a mass of 1 kilogram has an acceleration of 1 ms^{-2}
- 1 kilogram is the weight when a force of 1 Newton has an acceleration of 1 ms^{-2}
- An acceleration of 1 ms-2 is produced when a force of 1 Newton is exerted on a mass of 1 Kilogram.

Exercise: Make a list of as many three variable relationships that you know giving each variable in terms of the other two and making deductions regarding unit relationships as previously done.

This exercise forces the student to reflect on all known equations that fit the description (three variable relationship) and appreciate the interrelatedness of the various subjects that often are compartmentalised. The exercise also reinforces the importance of units in expressions to give better meaning and significance.

Compilation of a table of three variable relationships

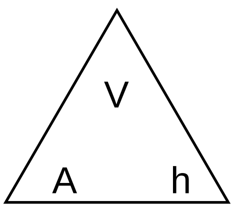
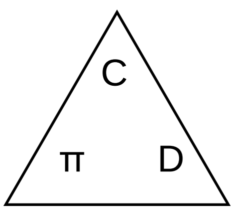
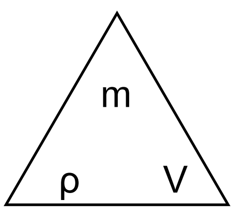
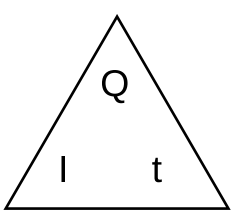
#	Triangle	Equation	Three variables list	Units	Subject you thought about first
1		V = Ah	V = Volume A = Area H = Height	m^3 or litres m^2 m	Math
2		C = πD	C= Circumference of a circle Π = 3.142 D= Diameter of a circle	m Constant m	Art
3		m = ρV	m = mass ρ = density V = volume	kilogram kilogram/m^3 m^3 or litres	Biology
4		Q = It	Q = Charge I = Current t = time	Columbs Amperes seconds	Electronics

Table 1 Three variable relationships

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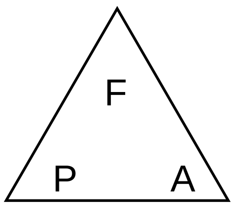
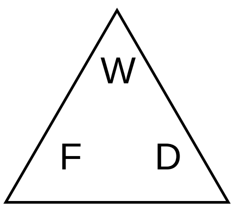
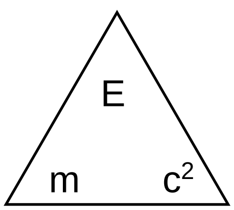
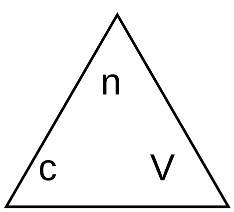
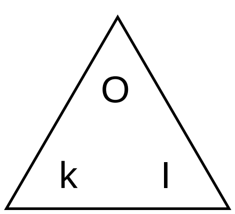
#	Triangle	Equation	Three variables list	Units	Subject you thought about first
5		F = PA	F = Force P = Pressure A = Area	Newtons Newtons/m^2 m^2	Physics
6		W = FD	W=Work done F = Force D= Distance moved in direction of the force	Joules Newtons m	Engineering
7		$E = mc^2$	E = Energy m = mass c = velocity of light	Joules Kilograms ms^{-2}	Astronomy
8		n = cV	n = amount of solute c= concentration of solution V = volume of solution	mol mol dm^{-3} cm^3	Chemistry
9		O = kI	O = Output k = constant I = Input	unit goods constant unit goods	Economics

Table 1 Three variable relationships cont'd

Conclusion

The triangulation theme is pervasive in all of life situations and highlight the importance of understanding basic principles of an equation. By definition an equation assumes equality of what is on the right hand side with whatever is on the left hand side of the equal sign. The mere fact that an equal sign is represented by two parallel lines that are exactly equal to each other should imply that an equation demands balance on both sides of the equal sign.

Based on this principle it is reasonable to assume that whatever operation is performed on the right hand side of the equation, the identical operation must be performed on the left hand side of the equation if balance is to be maintained. Anything short of identical operations on each side will result in an imbalance and the equation will no longer hold true. This means that any of the three variables may be expressed in terms of the remaining two variables. Units of measurement tell us how each variable is measured and this is important from the stand point of knowing how much of any given variable is present.

Examples taken from a variety of different subjects underscore the ubiquity of the triangulation theme: Art, Astronomy, Biology, Chemistry, Economics, Electronics, Mathematics, Physics, to mention a few. More importantly, by identifying different subject we minimise a natural tendency for many students to compartmentalise or mentally place information in separate compartments or mental slots. Unfortunately, compartmentalisation results in a brain that can only function for separate subjects and not holistically as the universe operates. The tendency to keep certain facts and ways of reasoning as belonging to particular subject areas, to the extent that such facts are not transferable to other subject areas is enormously minimised by understanding the pervasiveness of the triangulation theme across disciplines.

Thus, apart from bringing together commonalities this article serves to underscore the dangers of compartmentalisation and seeks to encourage thinking outside the box. By requesting that three variable relationships be identified in as many subject areas as possible the reader is forced to bring together ideas from different subjects, thereby undermining the tendency to compartmentalise.

The three variable relationship is merely the tip of the iceberg but clearly represents how relationships may be interpreted. It is no small wonder that repeating anything three times demonstrates significance and tells the listener that the matter is serious. Think of a judge who hits his gavel three times against the desk to denote finality of the decision arrived at. Think of the mother who counts to three (one…two…three) to give her child enough time to stop a particular action. Also think of a researcher who obtains information from at least three sources or uses at least three methods for data analysis to ensure that results of his research are reliable and valid. The repeated emphasis on three reinforces the observation of the three variable relationship in a variety of real life situations.

It is hoped that readers will become more sensitive to the threesome nature of basic scientific laws that govern the universe and find science much more engaging and exciting. Educators might consider paying specific attention to the triangulation pattern in relationships in order to improve teaching practices and enhance learning.

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