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Presentation Through Graphs or Thinking in Pictures

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Abstract

The great problem of every teacher is to present facts in such a way that the students cannot help seeing what is meant. A bald statement is soon forgotten. Vivid images remain in the memory. Many people must have noticed the difference between reading a history text-book and seeing an historical film. Whatever the relative accuracy of the book and the film, the film certainly makes one realize events more intensely, and remember them longer. In films it is sometimes necessary to explain quite complicated ideas, not to a class of students, but to an audience which represents the whole population of a country. Cinema audiences, too, are in no mood for concentrated thought. They want to relax, to be amused. It is extremely instructive to examine how film directors go about the job. They rarely fail to make their point understood-a fact which should be seriously considered by those defeatists in education whose perpetual alibi is the stupidity of pupils.

1. INTRODUCTION

Graphs have become so much a part of everyday life that it is not really necessary to explain them. People entirely without mathematical training are usually able to see the significance of the temperature chart over a patient's bed, of the curves showing changes in unemployment or the history of cotton exports. from arvind mill. Graphs are used to show the progress of a campaign to raise money, or the output of a factory. Business magzine contain graphs showing the trend of prices. At some holiday resorts one can see instruments which record curves, showing how the barometer has risen and fallen, and charts of the rainfall and sunshine from day to day. The general idea of graph is already widely understood.

2. METHOD TO DRAW A GRAPH

It may be useful to explain exactly how a graph is drawn. A graph illustrates the conneetion between two sets of numbers. For instance, we consider the possibility that a plant might grow as shown in the following table :

$$\text{Number of weeks } (x)\ 0\ \ \frac{1}{4}\ \ \frac{1}{2}\ \ \frac{3}{4}\ \ 1\ \ 1\frac{1}{4}\ \ 1\frac{1}{2}\ \ 1\frac{3}{4}\ \ 2$$

$$\text{Number of weeks } (y)\ 0\ \ \frac{1}{4}\ \ \frac{1}{2}\ \ \frac{3}{4}\ \ 1\ \ 1\frac{1}{4}\ \ 1\frac{1}{2}\ \ 1\frac{3}{4}\ \ 2$$

We draw a level line, along which we marked the number of weeks. We then drew lines upwards, representing the height of the plant corresponding to any number of weeks. In Fig. 2 such lines have been drawn corresponding to 1, $1\frac{1}{4}$, $1\frac{1}{2}$ and 2 weeks. The upright line corresponding to 1 weeks is 1 inch high-the size of the plant after 1 week. The upright line corresponding to $1\frac{1}{4}$ weeks represents the height of the plant after $1\frac{1}{4}$ weeks. So one can go on, drawing as many upright lines as one likes. These upright lines show the growth of the plant, in the same way that the plies of coins show the growth of the inventor's weekly savings. After drawing a large number of these upright lines, we can see that the tops all lie on a certain straight line. (In other examples the tops lie on a curve.) Drawing the line (or curve) joining the tops of the upright lines, we obtain the graph of the plant's growth. As the plant grows according to the formula $y = x$, this line is also called the graph of $y = x$.

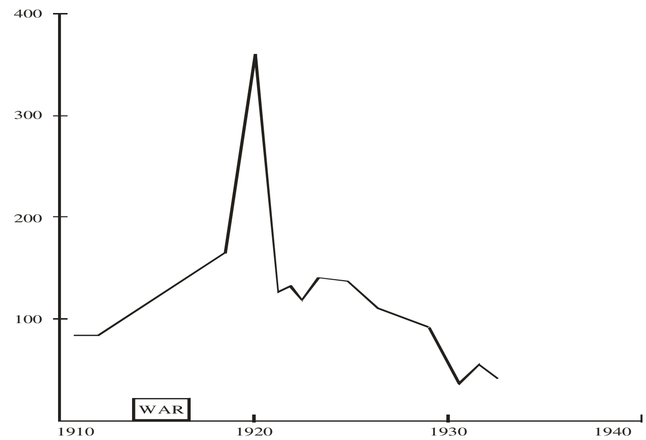
3. THE USES OF GRAPHS

Graphs have a great advantage over tables of figures, when information has to be taken in at a glance. It is quite easy to run an eye down a row of figures, and fail to see that one number is much larger than the rest. On a graph, such a number would stand out like a mountain peak. A sudden bend in a graph is easily seen - a casual glance at the corresponding figures would certainly not reveal its existence. Graphs are particularly useful for busy men who want to know the general outlines of a situation but do not want to be bothered by going into every small detail.

This is the simplest use of a graph - to convey a general impression. An historian or an economist may simply want to know that Lancashire was prosperous in 1920 and that a sharp crash.

4. GRAPHS AS A RECORD OF TRADE

The graph shows the exports of cotton cloth, in million pounds, during this years in question. One can see in a few seconds the general outline of Lancashire's fortunes in this period. One Would grasp far less from seeing the actual figures. Try for yourself taking a column of figures from an encyclopedia or year-book. Glance at them for fifteen seconds, put them away and write down the things you have noticed when the figures are largest



when they are small, when they are growing, when they are getting less, etc. You will not notice very much in a short time. Now make a graph of the figures, and notice how the graph brings out things you have missed. One glance at a graph of cotton exports will remind him of his fact. Again, graphs can be used to bring out the conneetion between two events. Most of books on Economics point out how the corruption corruption in economy created a mood of desperation, and helped the rise of the price. How far can we accept this view as being true? Let us draw, on the same piece of paper, two graphs, showing the amount of corruption in an economy.

This graph immediately shows that there is some truth in the idea. During the boom years, the elections returned negligible numbers of Nazi M.P.s. : 14 and 12. The two curves, in the main, rise together.

It would, however, be absurd to try to find a mathematical formula connecting the two things. The

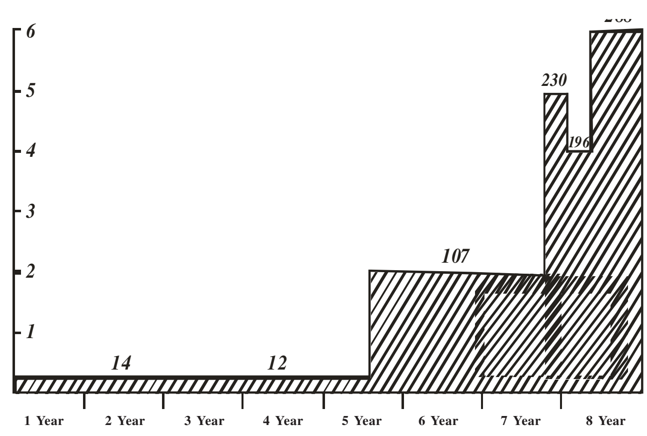


Fig. . Corruption Pise in an economy

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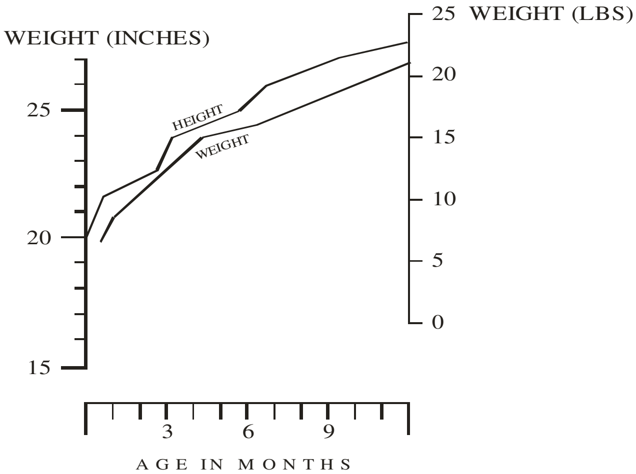
corruption changes by steps, at every general election. Unemployment and insecurity are not the only causes acting. You will notice how a graph calls your attention to unexplained.



The two graphs above the height and weight of a baby in the first year of its life. If the graph for weight does not keep pace with the graph for height, something is wrong. Facts, and urges you on to further We drew the graph to see how far the slump explained the rise of Hitler. The graph not only gives us an indication of the probate answer to this question : it brings to our notice the fall in the corruption vote at the end of year 7, which is in no way connected with the curve for unemployment, and sets us searching for further to explain the setback.

It is worth while to collect graphs on any subject in which one is interested. One often hears remarks, and wonders what evidence there can be for their truth. A visit to a public library will often establish the truth or expose the falsehood of a statement. If it is possible to illustrate the question by means of a graph, one has a way of recording much information in a little space. One need not look up the same facts again. As time passes, the collection of graphs is likely to contain some interesting facts.

Quiller-Couch, in The Art of Reading, mentions a girl who kept a graph of the attendance at a village church, and tried to account for every rise and fall that occurred. She must have gained an amazing knowledge of the qualities of the preachers and the habits of the village.

Graphs are used by doctors, to show whether children are being properly nourished. The weight of a child, and its height, are graphed on the same piece of paper. For a healthy child, the two curves go up together. If the child is not getting the food it needs, the curve for weight fails to keep pace with that for height. The doctor need not wait until there is a big gap between the two curves. If he notices that the curve for weight begins to bend downwards, this may be the first sign that something is going wrong. If, after special treatment or extra food, the curve begins to bend upwards again, the doctor knows that good effects are beginning to be felt. Part of the science of interpreting graphs consists in knowing how a graph looks when something is increasing, when it is increasing very fast, when it is increasing faster and faster, when it is increasing but increasing slower and slower.

In all these examples the conclusions drawn from the graph have been of a rather general nature. The doctor sees that a child is getting healthier or less healthy, but he does not attempt to measure how healthy it is. He cannot say that it is 80% healthy, happiness and honesty can be measured only indirectly : statistics of deaths, suicides, thefts may throw some light on the these matters. But it is quite possible to know a lot about how healthy, happy or honest a person is, without being able to give a single figure of anything that can be measured.

There are some departments of life, on the other hand, in which measurement plays a large part. This is particularly true of such subjects are engineering, chemistry, physics. quite a small bump on a railway track may be sufficient to derail a train : if a ball-bearing is one-thousandth of an inch too large, it may take all the weight that should be spread over several ball-bearings and wear out too fast. In such matters very exact calculations are frequently necessary. For this reason engineers and scientists cannot be content with rough statements. They sometimes want say, not merely that a curve rises slowly, but that it rises at a rate of 1 in 100, or in 87. Much of mathematics has developed in an attempt to satisfy such demands of engineers : mathematicians have been led to invent a whole set of numbers, by means of which one can not only describe, but measure, exactly what a curve is doing at any point. The next chapter-on the study of peed-explains how this is done.

5. MATHEMATICIANS AND GRAPHS

Mathematicians use graphs for many different purposes, some of which are indicated in the following paragraphs :

Graphs may be used to help us to know what we are talking about. If often happens when long calculations are being made with algebraic symbols that we lose sight of the meaning of these symbols; we have at the end a formula, which has been obtained by using the rules of algebra, but we have no way of feeling what it means. It deepens our understanding of the subject if we do not rest content with having found a correct formula, but try to realize what this formula means.

For instance, the formula :

$$P = 364\,V - \frac{V^3}{270{,}000}$$

gives the power (P) transmitted when a shaft is driven by means of a leather belt. V represents the velocity in feet per second at which the leather belt is traveling. The formula holds in certain conditions which do not certain us at the moment.

What does this formula mean? It contains a quite striking result. It would be natural to suppose that, by turning the driving pulley sufficiently fast, one could transmit as much power as once wished. But draw the graph of P, taking V for values between 0 and 8,000. You will find that P rises until V is 5,700, after which it decreases. If you drive the belt faster than 5,700 feet a second, you do not transmit more power but less. One glance at the graph shows this. If, however one did not draw the graph, but used the formula blindly, one might make serious mistakes, such as designing a plant which worked at a speed too high to be economical.

Graphs can be very helpful to anyone learning mathematics. Many people can follow all the steps in the solution of a problem, when the solution is shown to them, but they are unable to discover the solution for themselves. They understand each separate step, but they do not know which series of steps will bring them out of the wood. This difficulty can be overcome only if one learns to see the meaning of mathematical formulae. Many mathematicians think about their problems all day, wherever they may be. They do not remember all the formulae : they remember a picture which the problem has created in their minds. They keep thinking about this picture, until a method of solving the problem occurs to them. Then they go home to their pens and paper and collection of formulae, and work out the solution in full. Graphs are one of the ways by which it is possible to form a picture o a problem.

It is a good practice to collect and to become familiar with, the graphs of the more common functions, such as $y = x$, $y = 2x + 1$. $y = 3 — 2x$, $y = x^2$, $y = x^2 + 2x + 5$, $y = x^3$, $y = x^4$, $y = 2^x$, $y = \frac{1}{2}x$, and so on.

In scientific work one often obtains a set of results by experiment, and then tries to find a formula to fit these results. This can be very difficult, since there are many different types of formula, any one of which might be the correct one. It is often helpful to represent the experimental results by means of a graph. If one is familiar with the graphs of many functions, one may at recognize the type of function which produces such a graph. For instance, all functions which have straight lines as graph are of the type $y = ax + b$.

Of courses, small errors always creep in , and one does not expect the points to lie exactly on a smooth curve. Such small errors in measurement are due to various causes - the thickness of the lines on a ruler when a length is being measured, for instance. Occasionally a big mistakes occurs - for instance, one might copy 7197 as 7917, or forget to close a switch when an experiment was being done. Such big mistakes are easily detected on a graph. All the other readings cluster around a smooth curve, but the big mistake is far away from the curve, and one suspects it immediately.

This way of detecting errors is useful not for scientific work only, but also for mathematics itself. For instance, in calculating a set of numbers we may

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make slips in one or two of the members. By drawing a graph it is usually possible to see which numbers are incorrect. When all the members are correct, the graph will be a smooth curve - at any rate, this is true in the great majority of cases.

Graphs not only enable us to express a formula by a curve : they enable us to describe a curve a formula. For instance, when there is no wind, a jet of water from a hose or a small pipe forms a simple curve. If a board is held near the jet of water, the curve can be traced. One can then study this curve, and try to find the formula of which it is the graph. The formula, once found, provides a sort of name for the curve. The part of mathematics known as Analytical Geometry is based on this idea of describing every line or curve by the formula corresponding to it. If you want to learn analytical geometry, but find the text-books difficult, the best thing to do is to experiment with graphs for yourself. Draw graphs of the type y = ax + b, taking all sorts of values for a and b, positive and negative, large and small. Verify the statement made earlier that all these graphs are straight lines. What do you notice about the graphs of y = x and y = x + ? Can you find a formula which gives a straight line at a right angles to y = x? Experiment on these lines, record your experiments, and try to reach general conclusions : see how long it is before you can tell, simply by looking at the formulae, that two times are at right angles. Them read the chapter in the text-book headed 'The Straight Line' or 'The Equation of the Straight Line', and you will find your own results, in another person's language. Since you already know what the author is trying to say, it will not be long before you come to understand his language.

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