Innumeracy: Mathematical Illiteracy and Its Consequences Study Guide

Innumeracy: Mathematical Illiteracy and Its Consequences by John Allen Paulos

BOOKRAGS

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Plot Summary

John Allen Paulos is a mathematician, author, columnist, and professor at Temple University in Philadelphia, Pennsylvania. Paulos is best known for his devotion to mathematics, addressing mathematical illiteracy, and using humor as the basis for mathematics.

Paulos holds a Ph.D. in Mathematics from the acclaimed University of Wisconsin-Madison and has served on the Temple University faculty as a full professor since 1987. The author has also served as a visiting professor at the Columbia University Graduate School of Journalism during the 2001-2002 academic year.

Paulos claims that the initial purpose in writing Innumeracy: Mathematical Illiteracy and its Consequences was to respond to the overwhelming existence of mathematical illiteracy and general misuse. The author believes that many books are written due to anger and freely admits this book is one that falls into that category.

One of the author's most abhorred subjects is that of mathematical illiteracy and how it often goes unnoticed. A large number of people use math incorrectly, regardless of occupation or education. Paulos admits to taking delight in pointing out the misuse and muses that many people take a misguided pride in mathematical illiteracy.

There are a wide number of topics addressed throughout the book supporting Paulos' claims that there are harmful consequences caused by innumeracy. Because of the lack of ability in the mathematical arena, many people are forced to take low paying jobs or quit school, and some are not able to pursue the lifestyle of which they have always dreamed. There is also the greatly underestimated presence of math anxiety which often starts in childhood and can continue to plague even the brightest student throughout his entire academic career.

Paulos spends a great deal of time explaining probability and its various uses. The author also shows how many instances of probability are inaccurate or misused either through ignorance or for the benefit of skewing the final outcome to meet a particular expectation. There are also a number of sections related to coincidence and the tendency to focus on extraordinary events. This leads into the examination of parapsychology and its various sub-topics, all of which Paulos discounts as being scientifically unproven.

Overall, Paulos states that the search for additional information and statistics, which may be incorrect to begin with, is futile. The author has proven that most statistics are utterly meaningless and the world has more than enough information to determine population and other necessary elements of society. The author hopes for a movement that encourages schools to ensure that students have a sufficient knowledge of the basic functions of math and that society will, by and large, learn how to use those skills effectively and with great success.

Aside from his proficiency in mathematics, part of Paulos' appeal is his use of humor throughout the book. This entertainment value also translates to the author's other activities such as teaching and lectures for academic and corporate institutions.

Introduction, Chapter 1 - Examples and Principles

Introduction, Chapter 1 - Examples and Principles Summary and Analysis

There are many educated people in the world who consistently misuse math. While a grammarian may cringe over a misused word, one would rarely recognize an egregious error when another estimates probability. One example Paulos uses is a common error made by weather forecasters. A weather forecaster may announce that a 50 percent chance of rain on Saturday and a 50 percent chance of rain on Sunday means a there's a 100 percent chance of rain over the weekend, which is false. Paulos also finds that doctors are rarely correct in estimating a patient's chance for success during surgery. If a doctor says that there is one in a million chances of a mishap, then the follow up remark that the procedure is 99 percent safe is incorrect.

As a mathematician, the author claims to take a perverse pride in noticing these errors. Although common and glaring to the professional, many of these errors go unnoticed.

There are those innumerates who have little to no grasp on math, and then there are those like the Indian mathematician Ramanujan who see everything in mathematical terms. Paulos believes that most people are somewhere in the middle.

One way that people could correct these egregious errors is by using proper scientific notation in the media. Paulos wonders why people don't do this since scientific notation makes much more sense than the written word. It would also help people to understand the difference between one million, one billion, and one trillion.

In order to make sense of math, Paulos suggests that people find ways to make the math more personal. Paulos relates 1,000 to the approximate number of seats in Veteran's Stadium in Philadelphia (1,058) and relates 10,000 to the number of narrow bricks on his garage wall. If there was a way for each person to relate larger numbers to personal items, it would make much more sense. As it is, the misunderstanding of numbers can be easily compared to a sign that proclaimed New York has a population of more than six or that McDonald's has sold more than 120 hamburgers.

Archimedes made one of the most important and yet simple mathematical discoveries. The Archimedes Principle states that any number, no matter how large, can be achieved by adding smaller numbers together. Paulos agrees that the principle sounds elementary but also helps the innumerate to understand how mathematicians make calculations. A prime example of this type of calculation may be understood through exponents.

Another important principle mentioned in the book is the multiplication principle. If a woman has three skirts and two blouses, then there must be a formula to decide how many outfits the woman can create. In order to do this, one must take S3 x B2 to find the combination: S1 + B1; S2 + B1; S3 + B1; S1 + B2; S2 + B2; S3 + B2. The total number of possible outfits is therefore six.

An analog of the same principle can be used to determine probabilities.

Chapter 2 - Probability and Coincidence

Chapter 2 - Probability and Coincidence Summary and Analysis

Paulos starts off with a story about a man who was afraid of being on a plane with someone who had a bomb in his luggage. Although the man realized that such a thing was quite unlikely, the probability was still too high for his comfort. Therefore, the man began carrying a bomb in his briefcase since the chance of there being two bombs on board a plane was infinitesimal.

Sigmund Freud, the great psychoanalyst, once said that there was no such thing as coincidence. Carl Jung, a giant in psychiatry and analytical psychology, was fond of the topic of synchronicity. People seem to be obsessed by coincidence, synchronicity, and irony. Paulos states that despite what people choose to call these occurrences, the events are actually not as uncommon as people may think. It is focus on such coincidences that make the events seem rare or extraordinary.

The author uses several examples to prove this point. These examples include that fact that many people are aware that President Lincoln's secretary was named Kennedy while President Kennedy's secretary was named Lincoln. Christopher Columbus was credited with discovering the New World in 1492 while fellow Italian Enrico Fermi discovered the New World of the atom in 1942. Paulos is disconcerted by intelligent people who inquire about the author's zodiac sign and then correlate facts with his personality, even if given the incorrect information.

The formulas for explaining such "coincidences" are part of the author's forte. Among the examples used in the text, Paulos refers to chance encounters or the meeting of two strangers who magically have a third person in common.

To illustrate the point, the author uses the following scenario:

Two strangers living on opposite sides of the country happen to meet while on a business trip. Through conversation, Stranger 1 learns that his wife was in a tennis camp operated by an acquaintance of Stranger 2's wife. It is this type of coincidence that makes most people utter, "It's a small world!"

Paulos explains such encounters this way: Using the assumption that each of the United States' 200 million adults knows 1,500 people spread throughout the U.S., there is a 1 in 100 probability that two people will have an acquaintance in common. There is more than a 99 out of 100 chance that the strangers will be linked by two intermediates.

Paulos backs up this theory by a series of examples and case studies including those of shared birthdays. One mistake many people make is to look for a specific event opposed to a particular event when trying to prove the theory. For example, it may be

highly unlikely that two people in a crowd share the birthday of March 19, yet it is very likely that two people in a crowd will have a birthday in common.

Two highly celebrated cases of coincidence can be seen in the winning streaks of gamblers and stock market analysts. Most averages pointed out by either tend to be baseless. If one examines the laws of probability, one can see that there is bound to be a "streak" if enough games are played or stocks monitored. The key to both seems to be calling attention to the positive outcome of each situation while ignoring the unsuccessful outcome. For instance, a stock market analyst who encounters the probability that six out of his last seven tips are valid is more noticeable than one who predicts two, misses one, predicts two, and misses two. The same can be said with casinos. Every win is celebrated with flashing lights and the metallic sound of coins hitting the metal receiving tray. However, when a person loses, the machine and the person tend to remain silent.

Overall, extremes are pointed out more often. As the world comes closer together through media and electronic advances, the extremes seem more prevalent. As a result, people are beginning to expect more and more in every aspect of their lives. This is good news for the media but not nearly as good for those who are struggling to keep up with their performances.

Regardless of how rare an event may seem to be, the probabilities are quite predictable. Paulos explains the Poisson formula for probability distribution. The formula was developed by the French mathematician Siméon-Denis Poisson who asserted that probability of events can be determined if said events occur during a fixed period of time and have a known average rate. The events must also have occurred independently. Poisson also discovered that the formula can be used in other events that involve specific intervals such as area, volume or distance.

One final example of the misuse of probability is demonstrated by a court case in which a couple was prosecuted for a crime based on the probability that they were the perpetrators. The couple was convicted based solely on the probability, which turned out to be incorrect. The ruling was later overturned on appeal.

Chapter 3 - Pseudoscience

Chapter 3 - Pseudoscience Summary and Analysis

Paulos believes that "Innumeracy and pseudoscience are often associated, in part because of the ease with which mathematical certainty can be invoked to bludgeon the innumerate into a dumb acquiescence."

There are a great number of certainties in mathematics. However, these certainties can be misused if the basis of the problem is oversimplified, misstated, or simply taken out of context. In that case, substitutions which may be sensible in any other form may fall flat and prove to be completely incorrect.

Paulos uses the following example: If President Reagan believes that Copenhagen is in Norway, and we known that Copenhagen equals the capital of Denmark, it does not mean that President Reagan thinks that the capital of Denmark is located in Norway. This is one of the cases in which given the incorrect substitution values, 1 and 1 do not equal 2.

Even the most well educated people can suffer from innumeracy. Paulos uses a good example detailing surgeon Wilhelm Fleiss' invention of biorhythmic analysis. Fleiss introduced the theory that every person is subject to rigid periodic cycles that begin at birth. The periodic cycle for men is 23 days, while a woman's is 28 days. Also, any number could be reached by adding or subtracting any multiple of the two numbers.

Paulos demonstrates that any number can be reached through the equation 23X + 28Y, substituting any suitable number for X and Y. If X equals 10 and Y equals -8, then the formula would be 6 = (23 x 10) + (28 x -8).

Fleiss explained this theory to his good friend Sigmund Freud who was completely impressed and immediately became such a believer in biorhythms that he was convinced he would die at age 51. What neither Fleiss nor Freud understood was that the same principle can be applied to any two numbers are relatively prime, meaning that the two numbers do not have a common factor. Therefore, Paulos terms Freud as an innumerate.

There are other beliefs attributed to Freud that contain flaws. The statement "Whatever God wills, happens" is not falsifiable and therefore not a scientific statement. Another common adage is that "everything comes in threes." Paulos asserts that if one waits long enough, everything will come in threes. There are also many instances where predicted outcomes are defied and therefore rationalized away with a sort of "escape clause."

Paulos once encountered an incident where a student thought the professor believed in extraterrestrials simply because he had stated that there were many cases of UFOs. Somewhere along the line, the student correlated UFOs containing extraterrestrial

beings with UFOs as being Unidentified Flying Objects. Hence, the student's conclusion was incorrect.

The author points out several humorous instances where baseless drivel and double talk are often used to attempt to give weight to a non-scientific theory.

Paulos explores parapsychology as a pseudoscience. While extrasensory perception (ESP) is commonly accepted, there have never been any successful and flawless studies proving its existence. There may be scientific reasons for some parapsychological activity to be considered. For example, one may walk across hot coals without harming one's feet if dehydrated would were used, since dehydrated wood has a low heat content as well as a low conductivity ratio. Rather than delve into all areas in which parapsychology may define pseudoscience, Paulos recommends readers investigate the quarterly publication The Skeptical Inquirer, published by the Committee for Scientific Claims of the Paranormal (CSICOP).

Precognition, or the recognition of an event before it occurs, is a common parapsychological event, particularly in dreams. Paulos himself once experienced precognition when the author dreamed he hit a grand slam. Two days later, the author hit a bases loaded triple which corresponds closely enough. Paulos states, however, that such occurrences are simply coincidence. Coincidences, of course, can be explained through probability.

In defense of probability, many cite the unlikelihood of a monkey seated at a typewriter accidentally typing out Shakespeare's Hamlet. This of course, is nonsense. Consider this: If the first ratio of 1/35, one monkey and the 35 keys on a typewriter, is multiplied by N as a factor representing the number of characters in Hamlet, the probability of this occurrence is so infinitesimal as to be equal to zero. As Paulos jokes, this does not validate the theory of Creation Science but in fact shows only that monkeys seldom write great plays.

Astrology is another pseudoscience with which Paulos takes issue. The author is distraught by the notion that so many people subscribe to a theory in which the alignment of planets and stars, particularly if said person is one of notable power. First Lady Nancy Reagan was known to have a staff astrologist which may or may not have affected the politics of the United States as a whole.

Paulos' argument is that astrologists claim that the gravitational pull of the planets at the time of one's birth somehow affects one's personality. The author disputes this theory because 1) There is no proven physical or neurophysiological force that participates in this affectation, nor is this absence ever explained; and 2) The gravitational pull of the delivering obstetrician outweighs any planetary interference. Therefore, Paulos wonders if a baby's personality changes in correspondence to the physician's weight. If the obstetrician is fat, does the baby have a different set of characteristics than if the obstetrician is skinny?

Overall, Paulos attributes parapsychological events to coincidence and probability, the lack of another explanation, or from the parapsychologist making assumptions or taking clues from the subject.

Paulos states that innumerates are more likely to believe in extraterrestrials and UFOs than those with a scientific bent. The author does not discount that there is a probability of life elsewhere in the universe; the unbelief comes in reference to courtesy calls being paid by neighbors from outer space.

Through scientific calculation, it can be determined that out of 100 billion stars in the universe, approximately 10 million stars in our galaxy have the appropriate combination of factors to be able to support life. If even 1/10 of those stars do support life, why wouldn't we see any evidence of their existence?

Paulos cites reasons for the unlikelihood of visitations. One reason is that the closest neighboring star is approximately 500 light years away, or ten billion times the distance from the earth to the moon. Another reason is that the existences of specific types of life forms are bound to exist at different periods in time. The third reason Paulos states is that it is unlikely that these other life forms would have any interest in us as a people, particularly if the other life forms existed as giant clouds of methane gas, potato-like beings, or planet sized creatures that would rather spend their time singing complex symphonies.

Lastly, the author believes that Unidentified Flying Objects doesn't mean they are Unidentifiable Flying Objects.

The author believes that fraudulent medical treatments are the epitome of pseudoscience. According to scientific research, most ailments tend to cure themselves, are self limiting, or if fatal, rarely tend to behave in a strictly downward spiral. Therefore, it is easy for fraudulent medical treatment to seem effective or even miraculous. Regardless of the results of the treatment, there is a plausible excuse. If the patient gets well, the treatment worked. If the patient does not improve but stabilizes, the treatment has halted the progression of the disease. If the patient worsens or dies, then the patient simply waited too long to receive treatment.

One mundane error that is often made is to confuse the probability of A opposed to the probability of A given B or B given A. For example, if Myrtle has a sibling, A may prove that the sibling is a brother. However, A given B or the probability that Myrtle has a sibling who is B also younger, the outcome may change. A given B is different from B given A however. Once again, the outcome could be different if B given A means that there is a sibling who is younger and the probability is expected to reveal the younger sibling's gender.

Paulos also revisits the inaccuracy of medical tests and how the probability of receiving an inaccurate test result is much higher than the medical community would have us believe.

Paulos ends the chapter with a closer look at numerology, the author's favorite pseudoscience. One of the most widely known uses of numerology is apparent in the Bible. Numerologists believe that each number has significance. For example, the numerical significance of the Hebrew words "love" and "one" each equals 13. Since God = 'One," then love equals god. The two words together create the number 26, which is referred to throughout history.

For example, line 26 in Genesis states that God chose to make man in His image; there were 26 generations between Adam and Moses; and the numerical difference between Adam and Eve's names also equals 26. The Greeks also subscribed to numerology, including the total numerical value of the words "Yahweh," "good," and "holy." The words "Alpha" and "Omega" corresponded to "dove" and the numerical value of the letters in the Nile, 365, was a sure indication of the great river's annual floods.

Paulos also explores the birth of 666 as it pertains to the anti-Christ and the fact that just because one cannot dispute a fact doesn't give it validity.

Chapter 4 - Whence Innumeracy?

Chapter 4 - Whence Innumeracy? Summary and Analysis

Innumeracy is not only widespread, it is accepted much more than it should be. While there are many common places people may notice innumeracy, the most prevalent scenario typically involves a cash register. It is assumed that a cashier should know how to calculate tax and count change. The truth is that a great number do not. The advancements in technology continue to help these people by providing the answers for them yet in reality, the advancements are anything but - in fact, they are encouraging ignorance.

Paulos states that the most obvious reasons for innumeracy are poor education, psychological blocks and romantic misconceptions about the science of mathematics. The author had a negative early childhood experience regarding mathematics that, instead of scarring him as it might most children, the incident encouraged Paulos to study. After all, math is concrete and even if the other people don't like you, a correct answer is a correct answer. Elementary schools do manage to teach the algorithms for addition, subtraction, multiplication and division. They may also teach the kids how to handle decimals, fractions, and percentages. However, the problem lies in the fact that most kids don't know when to apply these functions. In addition, mathematics is rarely integrated into other class work. This may be one reason why some children grow up to fear word problems.

Another skill that is rarely taught to children is the skill of estimation. This is one skill that people use on a daily basis, yet it is often overlooked. Rounding numbers is usually addressed, which does help. However, being able to estimate the answers to every day problems continues to elude many. If only educators who bypass this valuable function would realize that learning to estimate affects every person, regardless of education, social status or occupation. Estimation allows us to figure out mortgage and car payments, calculate our car's miles per gallon, or figure out what kind of cereal is the best buy. Although children may never use their estimating skills to determine how many nickels it will take to fashion a life size model of the Empire State Building, it is a valuable tool, nonetheless.

Paulos believes that the lack of the study of informal logic in elementary schools is as uncommon as the study of Icelandic sagas. This is a mistake. Children would be able to adapt easily to the concept of informal logic through the use of puzzles, riddles and other interactive activities. The author also believes that the lack of these entertaining learning tools is often avoided because the teachers are afraid of being bested by a ten year old. Inadequate education can be blamed on many things such as budget and materials, but at least some of the fault has to be placed onto teachers who are mathematically incapable, improperly trained or simply don't care as long as students comprehend the most rudimentary operations. The schools must also take blame for

having little interest in the study of mathematics or perhaps neglecting to put policies in place that will encourage teachers and students to learn to use math effectively.

Lack of math skills in secondary education is at a critical level. If students do not possess the necessary skills and are pushed into yet another inadequate class, said student's future will tend to look rather bleak. Paulos asserts that many graduates will go on to work in the computer and investment banking industries and their education should support those choices. The author recommends that well educated math teachers be put into the schools, especially if they have real world experience in fields such as engineering or computer science. Said teachers should also be paid bonuses in order to encourage their performance as well as the performance of the students.

High school may be the last opportunity for teachers to effectively reach their students. Once a student graduates and heads off to college, it may be too late. It is not possible for a college level calculus professor to teach a student who has yet to learn algebra or even simple multiplication. The author says that it is common for people to go into fields of study that do not suit their skills or needs simply because of a fear of math. For those who do get through math or better yet, embrace the scientific concepts involved, job markets are much wider and more lucrative.

Although poor education is a great contributor to the problem, the author states that there are many people who are numerate despite the lack of formal training. Another, and perhaps larger, contributor to innumeracy is the presence of one or more damaging psychological factors.

One segment of the population embraces a sort of willful innumeracy due to the inability to relate mathematics to personal experiences. If a mathematical concept can not be directly related to a person's core issues such as money, sex and family, then it is considered to be invalid or perhaps unrelated to life and the world at large. When people compare themselves to others in their way of life, style, education, beauty or wealth, it is easy to fall short. However, we must remember that everyone has faults. It is also important to remember that the world involves other people and unless we take interest in other things, it is practically guaranteed that we will become depressed.

Paulos addresses ubiquity of filtering and coincidence as nothing less than a study in psychology. Which items one chooses to allow in and filter out of the minds creates the personality. The author asserts that the human tendency of searching for meaning can often lead one astray unless there is a reminder of the ubiquity of coincidence or the result of filtering out which things seem banal, impersonal or unimportant to one's life. What's left is a large number of coincidences.

Math anxiety is a topic that the author also addresses. Math anxiety most often comes from a traumatic experience or the belief that there are mathematical minds and non-mathematical minds. If a person doesn't instantaneously know the answer to a problem, that said person must have a non-mathematical mind. This is not true. Math anxiety can be overcome through practice, solving smaller problems, and the use of pictures and diagrams. Paulos also believes that anyone's math skills will improve through practice.

There are some people who may be beyond help. Those plagued with math anxiety can be helped and the same can be said for people who tend to be obsessive compulsive. Those who cannot be helped suffer from what Paulos refers to as "extreme intellectual lethargy." The sufferers of this ailment are those that lack any form of motivation, self-discipline, or simply don't care.

For thousands of years, there have been factions of people that believe that studying or understanding the finer points of mathematics numbs one's senses and therefore removes the ability to relate to anything on a grander scale. There are also ideas that math is a cold science which makes people impersonal. The author states that while math may seem cold, mathematicians are flesh and blood and express all the same emotions that other people do in the more romantic studies. Lastly, it is easy to describe mathematicians and scientists as "whizzes" and to move on without giving the topic any more thought.

Chapter 5 - Statistics, Trade-Offs, and Society, Close

Chapter 5 - Statistics, Trade-Offs, and Society, Close Summary and Analysis

The author examines the social effects of innumeracy and how these effects are harmful to the individual as well as to society as a whole. Paulos states that innumeracy also creates conflict between the individual and society.

There are several examples in which individuals are pitted against society. In essence, one may cooperate on behalf of society or choose not to cooperate on behalf of individualism. One good example is that of two drug traffickers who must make a hurried transaction involving brown paper bags. If each person takes the cooperative route, then each paper bag will be filled with either money or drugs. If one or both chooses to side with individualism, then one or both paper bags could be filled with nothing but shredded paper. Therein lays the conflict. The author also asserts that the choice between cooperation and individualism can be affected or even reversed dependent on the circumstances. In the case of the two drug traffickers, the choice may be affected by the value of the drugs or amount of money being paid.

Paulos revisits probabilities involving birthdays, death days, and ESP. The practice of calculating probability was thought to have started in the seventeenth century by participants in games of chance. During the same century, death statistics began to be recorded. While these studies can be terribly boring, the use of inferential statistics is quite useful in determining such things as population, making predictions, and testing the validity of various hypotheses.

Polling is one way in which people may estimate population or popular opinion. This is often done with consumer products and presidential candidates. If a random sample of the population is polled and 68 percent of respondents prefer candidate X, then it stands to reason that the poll is a reflection of the opinions of the entire population. One misstep in this practice, however, is if the sample is too small. For example, if 75 percent of all people plan to run out and buy the newest car, it may be that there were only four people polled and perhaps they were polled during a huge customer appreciation sale at a car dealership. While the public is rarely informed of such details, it can be noted that the larger the random sample, the more accurate the poll. The author also points out other factors, such as the standard confidence interval and the method of choosing the individuals to be polled.

Obtaining personal information remains important in creating certain statistics. Obtaining said information without invading one's privacy is becoming increasingly difficult. There are a number of ways to do this from flipping a coin to having participants answer blindly to what the author refers to as the capture-recapture method. The

capture-recapture method is seen quite often in regards to wildlife to determine the population of a particular animal in a specified geographic area. An example involving the population of fish illustrates the principle well. If conservationists want to determine how many fish are in a lake, they might capture 100 fish, mark them in some way, and then put them back into the water. The next step is to recapture 100 fish from the same lake. If eight of the fish caught the second time have the markings placed earlier, conservationists may assume that the number of marked fish in the lake is eight percent.

Paulos writes about two theoretical results regarding probabilities. The first deals with the law or large numbers which may be the most significant and yet the most misunderstood theorems regarding probability. The theorem simply states that the difference of the probability of an event and its actual rate of occurrence will eventually equal zero. However, it is common for people to misuse this theorem to arrive at some bizarre outcomes.

The second theorem is called the central limit theorem. This theory states that the average or sum of a large number of measurements travel along a normal curve even if the measurements themselves do not.

Correlation and causation are two things that the innumerate is prone to misunderstand and misuse. It is common for two quantities to be correlated without one being the cause of the other. Paulos states that there are times when the correlated quantities are casually related but that relationship may be obscured by other factors. There are also many accidental correlations, which may or may not be contrived and completely useless.

There are hundreds of statistics that are cited as the gospel truth when in fact they are inaccurate or simply untrue. Paulos uses the statistical rate of a woman's chance of getting breast cancer. If the statistic that one in eleven women is prone to getting breast cancer is properly explained, then most women will realize that in order to fall into that specific category, they will have to live to be 85 years old and fall into a specific age bracket at the time of the occurrence.

Fractions and percentages are also commonly misused and misunderstood. Paulos states that when a person cites a fraction or percentage, said person should also give an appropriate frame of reference. Two examples: If a dress is on sale for 40 percent off, then goes on sale for an additional 40 percent off, the actual reduction of the garment is 64 percent, not 80 percent. If a company announces that profits have gone up by 12 percent, it should also say which department this figure applies to, although the company would most likely ignore any decreases in other departments. In the end, percentages and statistics range widely depending on what factors are added or subtracted from the mix.

Paulos ends the chapter with miscellaneous odds and ends. The first topic is the seduction of averages. The ability to estimate averages is a valuable skill if used properly. If used improperly, averages may be utterly inaccurate or simply worthless.

Paulos refers to a man who sat with his head in the oven, feet in the refrigerator, but he was fine because on average the man was quite comfortable.

Randomness is not as easy to achieve as one might believe and as such the pollster is not always successful in the quest for information. Random information is essential when determining the validity of a hypothesis or to ensure fair gaming and polling operations.

Statistical significance and practical significance are two topics that are often confused yet they remain completely separate. If something has statistical significance, it simply means that it most likely could not have occurred by chance. Practical significance, on the other hand, may contain interesting data but holds no statistical value.

In closing, Paulos states that while probability plays a large part in each person's life, developing an appreciation for it may take a long time. The world does not need more statistics and facts to explain what is happening in society; rather society needs to gain a better understanding of the statistics and facts we already have. People must come to realize that logic and probability are not reserved for mathematicians and scientists.

Characters

John Allen Paulos

John Allen Paulos (1945 -) is a mathematician, author, and full professor at Temple University in Philadelphia, Pennsylvania. Paulos is best known for his devotion to mathematics, addressing mathematical illiteracy, and using humor as a basis for mathematics.

Paulos grew up in Milwaukee and Chicago and received a Ph.D. in Mathematics from the acclaimed University of Wisconsin-Madison.

Part of Paulos' appeal is the entertainment value the author adds to his teachings, writings, work and lectures for academic and corporate institutions. Paulos is considered to be a relatively humorous presenter and a notorious showman. The professor's classes at Temple University are extremely popular and always full, regardless if the subject is part of the required undergraduate program or more advanced curriculum.

One of Paulos' most abhorred subjects is that of mathematical illiteracy and how it often goes unnoticed. A large number of people use math incorrectly, regardless of occupation or education. Paulos admits to taking delight in pointing out the misuse and muses that many people take a misguided pride in mathematical illiteracy.

Paulos has served as a full professor at Temple University since 1987 and during the 2001-2002 academic year served as a visiting professor at the Columbia University Graduate School of Journalism. In addition to the professorship, Paulos is a regular contributor to ABCNews.com with a column titled "Who's Counting" and has appeared in hundreds of publications and programs for entities such as the BBC, New York Times, LA Times, UK Guardian, Chicago Tribune, Time Magazine, Business Week, Christian Science Monitor, Boston Globe, Washington Post, NPR, and many more. Paulos has also received a number of prestigious awards.

A great deal of acclaim has been awarded to Paulos for his many published works including Innumeracy, Mathematical Illiteracy and its Consequences; A Mathematician Plays The Stock Market; Beyond Numeracy; A Mathematician Reads The Newspaper; Once Upon A Number; I Think, Therefore I Laugh; and IRRELIGION: A Mathematician Explains Why the Arguments for God Just Don't Add Up.

Archimedes

Archimedes (c. 287 BC - c. 212 BC) was often referred to as Archimedes of Syracuse, son of an astronomer and reputed relative of Hiero II, King of Syracuse. Archimedes lived on the Syracuse-ruled state of Sicily and was reported to live there for most of his life, except for a period when he studied in Alexandria, Egypt. Archimedes, a supposed

follower of Euclid, was known as a Greek mathematician, inventor, engineer, physicist, and astronomer. While little is known about his life, Archimedes is considered to be one of the great minds of the ancient scientific community.

Archimedes was a prime example of "mother is the necessity of invention," proven by his first invention, the Archimedes Screw. The Screw was a type of hand pump that allowed Egyptians to irrigate their fields directly from the Nile. Archimedes' greatest accomplishment was the discovery of the volume of a cylinder, which was proven to have equal width and height. There is an unsubstantiated tale of Archimedes' discovery of the volume of solids. Supposedly, Archimedes was challenged with the task of determining if Hiero's new crown was solid gold. While taking a bath, Archimedes discovered water displacement could determine volume. Excited, the mathematician ran naked into the streets, crying, "Eureka, I have found it!"

Archimedes is also credited with the invention of the lever, the determination of the circumference of the earth, length of the year, and the building of a machine that accurately measured the angles of a rising sun.

Archimedes was engrossed by his work when mistakenly killed by a soldier during the Siege of Syracuse in 212 B.C.

Plutarch

Plutarch of Chaeronea (46 - c.122) was an author of moral treatises and considered to be the most influential Greek philosopher in history.

Julius Caesar

Julius Caesar (49 B.C. - 44 B.C.) was the most famous dictator and Emperor of Rome, credited with bringing about great changes in politics. Caesar was also known for his relationship with Cleopatra, Empress of Egypt.

Srinivasa Ramanujan

Srinivasa Ramanujan (1881 - 1920) was considered to be one of India's most celebrated mathematical geniuses. Ramanujan, a child prodigy, was credited with making substantial contributions to the field of mathematics through his work on continued fractions, infinite series, mathematical analysis, elliptic functions, and number theory analysis.

Wolfgang Amadeus Mozart

Wolfgang Amadeus Mozart (1756 -1791) was a prolific and unconventional Viennese composer of the Classical era.

G. H. Hardy

G. H. Hardy (1877 - 1947) was a prominent English mathematician, credited for making significant contributions to mathematical analysis and number theory. Hardy was also a mentor to Indian mathematician Srinivasa Ramanujan.

Douglas Hofstadter

Douglas Richard Hofstadter (1945 -) is a Pulitzer Prize winning author and American academic whose work revolves around consciousness, the nature of thinking, and creativity.

Raymond Smullyan

Raymond Smullyan (1919 -) is an American logician, philosopher, mathematician, magician, and recipient of a Ph.D. from Princeton University.

William Van Orman Quine

William Van Orman Quine (1908 - 2000) was a logician, mathematician, and author who reigned as Harvard's Edgar Pierce Chair of Philosophy from 1956-2000.

Sigmund Freud

Sigmund Freud (1856 -1939) was an Austrian physician who founded the concepts of psychoanalysis, the ego and the ID.

Objects/Places

Temple University

Temple University is located in the suburbs of Philadelphia, Pennsylvania. Temple College was chartered by Dr. Russell Conwell in 1884 and officially became the fully accredited Temple University in 1907. The University currently offers 300 academic degree programs and is attended by 34,000 students, from the main campus in Philadelphia and through study abroad campuses located in Rome and Tokyo, with programs located in Paris, London, Beijing, and Mumbai.

Temple has a rich history, as it is the second oldest dental school in the United States. The School of Dentistry, established in 1863 as the Philadelphia Dental College. Temple University also made history with the founding of the Temple University School of Medicine in 1901. Temple remains unique in that it is only one of three universities in Pennsylvania that is funded by public monies yet is independently operated. The other two universities in this vein are the University of Pittsburgh and Lincoln University.

John Allen Paulos has been a full professor of Mathematics at Temple University since 1987. Paulos is considered to be among the university's most recognized and in demand staff members. In 2002 Paulos received Temple University's Creativity Award.

Philadelphia, Pennsylvania

Located on the shores of the Delaware and Schuylkill Rivers in southeastern Pennsylvania, Philadelphia is one of the oldest cities in the United States and considered to be the birthplace of a nation. It is currently ranked as the sixth largest city in the U.S.

Known as the City of Brotherly love, Philadelphia once served as the capital of the United States. It remains an undying symbol of patriotism and houses some of the most significant historical cites in the country. Among the city's famous artifacts are Independence Hall, the Liberty Bell, Betsy Ross' House, Washington Square Park, Christ Church, Congress Hall, and Carpenter's Hall. Many famous patriots are married with Philadelphia including inventor, author and statesman Benjamin Franklin. Philadelphia was the site on which the Declaration of Independence was signed, proclaiming the colonies' separation from the British in 1776.

Philadelphia is also home to a number of prestigious educational facilities such as Temple University, University of Pennsylvania, and Drexel University.

Milwaukee, Wisconsin

Located on the shores of Lake Michigan, Milwaukee, Wisconsin is the 22nd largest city in the United States, most well known for its breweries. Milwaukee is also where Paulos spent part of his youth.

Chicago, Illinois

Located on Lake Michigan, Chicago is the largest city in the Midwest and is often identified with sports teams, political corruption, and Al Capone. Chicago is also where Paulos spent part of his youth.

Columbia University

Located in New York City, New York, Columbia University is a prestigious academic facility. Paulos served as a visiting professor at the Columbia University Graduate School of Journalism during 2001-2002.

University of Wisconsin at Madison

University of Wisconsin-Madison is considered to be one of the most highly recognized educational facilities for mathematicians. John Allen Paulos' alma mater.

Harvard University

Located in Cambridge, Massachusetts, Harvard University is one of the oldest and most prestigious Ivy League schools in the United States.

The Massachusetts Institute of Technology (MIT)

The Massachusetts Institute of Technology (MIT), located in Cambridge, Massachusetts, is considered to be the premier learning institution for mathematics and science in the modern world.

Princeton University

Located in Princeton, New Jersey, Princeton University is an Ivy League school considered to be one of the most prestigious learning institutions in the United States.

Greece

Greece is through to be home to the greatest scientists, philosophers, astronomers, and mathematicians in world history.

Themes

Innumeracy

Innumeracy is the basic term used for mathematical illiteracy. Innumeracy is common throughout the world in varying degrees and is the bane of author John Allen Paulos' existence.

Surprisingly, innumeracy runs rampant through society irrespective of the chosen walk of life, social status, gender, and generation. Even more surprising is that innumeracy is not restricted to the uneducated. In fact, the presence of innumeracy among the educated is extremely common. So common, in fact, that it is often overlooked the way a senseless cliché is overlooked.

Paulos gives many examples, some of which are humorous. Among the author's favorites is the weather forecaster who unknowingly presents his innumerate status to the world at large through the weather report. One forecaster claimed that there was a 50 percent chance of rain on Saturday and a 50 percent chance of rain on Sunday. Therefore, the weekend promised a 100 percent chance of rain. Another common example involves medical predictions. People often want to know the success rate of a particular surgery or health issue. Many times a doctor or other medical person may say that there's only a one in a million chance that something could go wrong. In the same breath the medical person may then say that this means the surgery has a 99 percent success rate.

There are a number of reasons for innumeracy. Two of the most prevalent are poor education and psychological barriers. While poor education cannot be called the sole factor in creating a class of innumerates, it certainly plays a large part. The author believes that mathematics must be used effectively and integrated into a child's schoolwork in order to create a firm foundation. If a firm foundation is not laid then all other building blocks placed on top will crumble.

The second factor is also extremely common. Many people, particularly women, suffer from math anxiety. Math anxiety typically occurs when one believes or is taught to believe that mathematics is beyond one's comprehension. Therefore, many anxious people believe that mathematicians are walking computer systems that have innate knowledge of mysterious formulas and theorems that are not available to the outside world. Many women suffer from math anxiety because they are told that girls aren't supposed to be good at math or that math isn't an important subject for a female to learn.

Paulos states that the world doesn't need more statistics, rules and laws for solving mathematical equations. Rather, people need to learn to use the basic tools so that the information we already have will make some form of sense.

Misconception

There is a great deal of misconception surrounding the science of mathematics. Ever since the development of the first mathematical formula there have been certain connotations surrounding mathematics and mathematicians. The average person saw mathematicians as wizards, mystics, and eventually, people of science. Being able to add, subtract, multiply, divide and perform other noteworthy functions seemed so foreign that surely it could only be performed through magic.

In the modern world, there are many people who still see mathematics in this way. For some, mathematicians seem like a group of walking computer systems, ready at any moment to spew out long complicated lists of statistics, theorems, probabilities, and ratios. It is a complex science that is so unfathomable to some that the entire subject is best left alone.

Another misconception is that mathematics is a cold science that deals only with hard numbers, that it is linear and uncreative. This is not true. There are many creative minds in mathematics. After all, it takes a great creative mind to develop new theories and formulas where none previously existed.

One of the most confounding misconceptions is that the understanding of mathematical concepts is reserved for a privileged few and the rest of the world is destined to walk around holding a calculator with a dazed look in their eyes. This is also not true. Nor is the statement that "girls aren't supposed to be good at math" just as "boys aren't supposed to be good at English." The same goes with the inference that someone will or will not have a great aptitude for math simply because of the abilities of a parent or sibling.

It is unlikely that misconceptions will ever disappear but the author feels that it is his duty to try.

Education

While poor education may not be the sole factor for the misapplication of mathematical skills, it is certainly to blame for a large percentage of people who are completely inept in this valuable science. Education in mathematics should begin before a child starts school and should continue well beyond college level.

Paulos does not attempt to blame all educational lapses on math teachers. The teachers certainly have a share of the blame, as do schools, parents, and the students themselves. However, there are math teachers who are not properly trained or educated well enough to be able to teach the assigned curriculum. Additionally, while the basic functions and operations may be taught, they are rarely applied in such a way that encourages students to understand how mathematics will apply to every day life. It is extremely common for a student to say something like, "When am I ever going to use this in real life?" While not every student will have a daily use for calculus, every student

will have a daily use for adding, subtracting, multiplication, division, fractions, and percentages. It is startling the number of middle school and high school students that don't possess even these basic skills.

At some point during their education, some students simply give up. Perhaps there was an embarrassing or humiliating event involving mathematics, such as an incorrect answer written on the board in front of the whole class. It would be worse yet if the teacher ridiculed or chastised the child for the mistake. Others have not had sufficient learning opportunities or simply "don't get it."

Regardless of the reason, something must be done so that students have the opportunity to take part in what is a great and important part of every day life.

Style

Perspective

John Allen Paulos is a mathematician, best selling author, columnist, showman, and full professor at Temple University in Philadelphia, Pennsylvania. Paulos is best known for his undying devotion to mathematics, addressing mathematical illiteracy, and using humor as a basis for mathematics.

The author has published numerous articles and books, many of which have garnered critical acclaim. Paulos' bibliography includes Innumeracy, Mathematical Illiteracy and its Consequences; A Mathematician Plays The Stock Market; Beyond Numeracy; A Mathematician Reads The Newspaper; Once Upon A Number; I Think, Therefore I Laugh; and IRRELIGION: A Mathematician Explains Why the Arguments for God Just Don't Add Up. Paulos is also a regular contributor to ABC.com with a column titled, "Who's Counting?"

Paulos holds a Ph.D. in Mathematics from the acclaimed University of Wisconsin-Madison and has taken his love of mathematics to the classroom and also making appearances at a wide number of venues and on radio and television shows.

One of Paulos' most abhorred subjects is that of mathematical illiteracy and how it often goes unnoticed. A large number of people use math incorrectly, regardless of occupation or education. Paulos admits to taking delight in pointing out the misuse and muses that many people take a misguided pride in mathematical illiteracy.

Therefore, the author's perspective on this work is that of a dyed in the wool mathematician, scientist, educator, and frustrated observer. It is Paulos' wish to uncover the misconceptions and fears surrounding mathematics so that the majority of the public would be able to apply its principals soundly and accurately.

Tone

The tone of Innumeracy, Mathematical Illiteracy and its Consequences is subjective for a large portion of the book. As a mathematician and educator, John Allen Paulos has very strong opinions about innumeracy and the negative consequences it has on an individual and society as a whole. Paulos is well known for using humor in his speeches and writings, which adds an element of interest for the listener and reader. It is the author's humor that makes the material palatable and the anecdotes used throughout the book are relevant to the lives of the average person so that the examples have meaning regardless of education, occupation, social status or gender.

The parts of the book that are objective deal mainly with actual mathematical functions, formulas, and theorems as well as historically documented facts. There are sections in which Paulos describes certain mathematical aspects in great detail in an objective

manner. Perhaps the most common of these is the determination of probability and the way in which people misuse it on a regular basis, either through ignorance or in order to serve their particular needs.

Although Paulos admits to writing the book because of a lingering anger and resentment toward mathematical illiteracy, the tone of the book does not reflect an angry or hostile man. Instead, the author's work is informative while managing to come across as caring and humorous.

Structure

The structure of Innumeracy, Mathematical Illiteracy and its Consequences is simple and straightforward. There is a short introduction to the material which is approximately two pages in length. There are a total of five chapters with a total page count of 135. Chapter One, Examples and Principles, is 19 pages long; Chapter Two, Probability and Coincidence, is 24 pages long; Chapter Three, Pseudoscience, is 23 pages long; Chapter Four, Whence Innumeracy?, is 27 pages long; Chapter 5, Statistics, Trade-Offs, and Society, is 34 pages long; and Close, the final word is 2 pages long. The introduction and closing not withstanding, the average length of the chapters is 25 pages.

In addition to chapter separation, Paulos uses separators inside each chapter to make specific points relevant to the text. These separators break the text into more manageable pieces and allow the reader to separate and identify individual topics. The average length of these subtopics is approximately 3 pages per topic.

The overall structure of each topic is well written, clear, and concise.

Quotes

"Innumeracy, an inability to deal comfortably with the fundamental notions of number and chance, plagues far too many otherwise knowledgeable citizens."
Pg. 3

"Why don't news magazines and newspapers make appropriate use of scientific notation in their stories?"
Pg. 9

"A concern with scale has been a mainstay of world literature from the Bible to Swift's Lilliputians, from Paul Bunyan to Rabelais' Gargantua."
Pg. 12

"If people were capable of estimation and simple calculation, many obvious inferences would be drawn (or not), and fewer ridiculous notions would be entertained."
Pg. 13

"It is no great wonder if, in the long process of time, while fortune takes her course hither and thither, numerous coincidences should spontaneously occur."
- Plutarch
Pg. 25

"A tendency to drastically underestimate the frequency of coincidences is a prime characteristic of innumerates, who generally accord great significance to correspondences of all sorts while attributing too little significance to quite conclusive but less flashy statistical evidence."
Pg. 26

"Coincidences or extreme values each catch the eye, but average or "expected" values are generally more informative."
Pg. 34

"Innumeracy and pseudoscience are often associated, in part because of the ease with which mathematical certainty can be invoked to bludgeon the innumerate into a dumb acquiescence."
Pg. 49-50

"To subject people who test positive to stigmas, especially when most of them may be false positives, is counterproductive and wrong."
Pg. 67

"Why is innumeracy so widespread even among otherwise educated people?"
Pg. 72

"Seldom are arithmetic problems integrated into other schoolwork - how much, how far, how old, how many."
Pg. 73

"I'm always amused by commercials for banks which tout their personalized service, which service amounts to a poorly trained and badly paid cashier saying 'Good morning' and then promptly fouling up your transaction."
Pg. 91

Topics for Discussion

How does probability affect your general decision making process?

Is it safe to say that all coincidences can be scientifically proven? Explain.

How might the probability ratio change regarding common acquaintances if the average American adult knew 2,000 people? What if the average number was 2,500?

Test the probability ratio of flipping a coin 50 times. Is the outcome as you expected? Explain.

Think of an incident in your life where you think the Poisson distribution formula would not work. Discuss.

Do you think it's possible to have every superstition and paranormal claim substantiated? How?

Of numerology, astrology, phrenology, faith healing and the existence of extraterrestrial beings, which do you feel is the most easily explained? Discuss.

After reading this book, would you consider yourself to be an innumerate? Explain.