The life and work of euclid

While studying geometry with Euclid a youth inquired after having learned the first proposition, “ What do I get by learning these things?” Euclid called a slave to them and said, “ Give him threepence, since he must make a gain out of what he learns.” [8]

Euclid, a Greek mathematician and teacher, changed the course of the world. Euclid’s work not only affected the work of other prominent scientists to come after him, but also the lives of ordinary people, which contributed to the rise of modern science in western civilization. What is perplexing is that despite him changing the course of world, we know very little about him. Unlike some other well-known historical figures, Euclid’s influence did not spread simply by fame. Historians don’t even know his exact date of birth. To this day, we do not know which continent he was born on, much less the city. Of the little we do know about Euclid, we know that he taught in Alexandria around 300 B. C. [9], and that he wrote, amongst approximately 10 other books, arguably one of the greatest mathematical textbooks in history, The Elements.

The Elements is a geometry textbook that unified all of the previously known principles of geometry. It was unique in that it was constructive in its delivery of its principles. Basically, it explained mathematic principles from the ground up and added onto what was already established. Imagine trying to study science if one concept didn’t flow into the next and everything was garbled and out of order. The Elements solved this problem through careful organization and logical delivery of its principles. The Elements wasn’t a revolutionary observation or a new and exciting revelation, but rather a book of brilliant deductive reasoning, analysis, and organization. The Elements

was explained so well that every Geometry textbook preceding it was practically discarded, and because of this the term “ Euclidean” wasn’t necessary or used for over two thousand years because there was no other known form of geometry[17].

Concerning Euclid’s deductive reasoning and analysis, his axiomatic systems are most prominent. His axiomatic systems are considered to be constructive. [18] This means that he never reached any conclusions or spoke about concepts that he did not yet explain to the reader. He arranged the geometric theorems so that they flowed logically from one to the next. [9] For example, he started with the simplest of concepts such as describing a geometric point and worked his way into derived propositions. [16] More specifically he took a small number of axioms (self-evident logical truths) and deduced many other theorems from them. He even filled in the blanks whenever it was necessary by filling in the missing steps absent from other’s processes, and even by developing his own proofs [9]. For example, Euclid proved that it is impossible to find the largest prime number. He proved that if you were to take the largest known prime number and 1 to the product of all the prime numbers leading up to it and including it then you will get another prime number. This is accepted as being one of the classics proofs in mathematics because of how clear and concise it is. [5]

Euclid put a lot of effort into making it possible for common people to understand geometry rather than just professional mathematicians. How the natural flow and style of explanation of The Elements affected the world is self-evident. Since it is easier to understand scientific concepts when they are communicated clearly and concisely and delivered in a logical order,

Euclid’s book made it much easier for the people to acquire a complete understanding of geometry. As newborns in this world often one of the first things we get to play with are blocks of different geometric shapes. This helps us to develop our minds both visually and mathematically. Euclidean shapes are quite literally everywhere in our society. Unlike Calculus where there is usually a fixed method for solving a given problem, when it comes to geometry, using Euclidean axioms allows people to solve any one problem in several different ways. It also inspires development of problem solving skills.

One of the ways Euclidean geometry has been applied and influences our day to day lives is through construction and architecture. For example, if somebody wants to construct a wooden table. If they wanted to figure out if it was square or not they could measure each corner of the table to see if it was at a 90 angle. With Euclidean Geometry, however, they would need only to measure two of the corners. The properties of right triangles within The Elements tells us that if two corners are square then the whole shape is square. This is probably very obvious to a person of our modern day, but it was not at the tme. Unless you are a mathematician you may not even know who such properties can be attributed to and just consider them common knowledge. Another, less obvious way they could have done this is to have measured the distance between two diagonal corners of the table. If the two distances are the same then the table must be a square. The latter method I have described is a common way for construction workers or home-improvement workers to check their work. There are countless examples of this that common people can utilize in their everyday lives with the principles of Euclidean Geometry. Euclid’s influence doesn’t end there.

Examples of Euclidean geometry can be found in modern day computer graphics. It is used in mesh generation. A mesh is basically a combination of geometric polygons or polyhedrons that create the illusion of a curve. Although the Euclidean Geometry may be widespread within western civilization, in some third world countries there are houses are constructed as lop-sided indeterminate shapes. This is a real-life example of what our architecture would have looked like without Euclid's influence.[4]

It is fair to say that the study of Euclid's book was one of the main contributing factors to the Scientific Revolution and subsequently the rise of science in Europe rather than in Asia. The Elements made the concept of one principle being built upon another glaringly obvious and, over the course of time, it became considered common knowledge in western civilization. Of course, scientists such as Newton, Copernicus, Kepler, and Galileo played significant roles as well [9], but as Sir Isaac Newton said " If I have seen further it is by standing on the shoulders of giants" [21]. Euclid's book provided for us, not just a " shoulder", but an entire foundation built of " giant's shoulders" that would have otherwise been scattered and disorganized. This solid base of knowledge allowed western civilization to reach new heights. For example, when it came to Isaac Newton and his book, Principles Of Natural Philosophy, many of his proofs were set in a " geometric form" similar to those found in The Elements. [12]

As it is with any great work of science, The Elements allows others to build upon it or advance into new areas of discovery. Some men, such as Girolamo Saccehri, have tried to disprove or find flaws in Euclid's axioms. Saccehri was an Italian mathematician who in 1733 almost discovered a form of non-

Euclidean geometry. He studied for years to find a flaw in Euclid’s work. He was supposedly on the verge of a breakthrough but gave up before his work came to fruition. It wasn’t until about a hundred years later in 1899 that a German mathematician by the name of David Hilbert found another set of geometric axioms that differed from Euclid. [13] Non-Euclidean geometry allows us to describe physical space in new ways. Following Hilbert came another German, by the name of Albert Einstein. Einstein recalls receiving two gifts that had particular influence on him as a child, one a magnetic compass, and the other Euclid’s The Elements. He referred to The Elements as the “ holy little geometry book”. [3]

Another example of a great scientist that was influenced by Euclid is Galileo Galilei. In his old age Galileo told his biographers that while attending the University of Pisa he would nose-drop in on lectures being given by Ostilio Ricci to the court pages on Euclid. These lectures were only available to members of the court so he would try to stay quiet whenever he attended them. His interest in Euclid got the better of him after a while and he approached Ricci to ask him questions on Euclid. Ricci noticed Galileo’s talent for math and eventually became his teacher. Although Galileo was supposed to be going to college to study medicine, (Galen) he secretly studied mathematics (Euclid) instead. Galileo later used Euclid’s Book Five, Definition Five, to show how bodies of certain arbitrary weight have weights directly proportional to their volumes. [2] This is one of the best examples how influential Euclid’s work was to anybody with a mind for mathematics and how he changed the course of history by capturing the interest of a man such as Galileo.

Euclid’s work also influenced philosophers such as Benedict Spinoza. Benedict Spinoza was a prominent philosopher of 17th century. He wrote the ambitious philosophicical book Ethics where he attempts to provide us with a coherent view of the universe and our place in it. To explain such concepts he used Euclid’s style of delivery complete with axioms and propositions. Speaking of the system within his book and the style in which he chose to present it in Spinoza said that it was “ demonstrated in geometrical order”. [23] Usually philosophical books were written differently, such as Rene Descartes’ Meditations that was written like a diary.

When it comes to mathematicians I think every mathematician alive since the time of Euclid had to have been influenced by his work in some form or another, but, of some of the most prominent mathematicians, Euclid specifically influenced the work of Bertrand Rusell, Alred North Whitehead, Blaise Pascal, Marin Mersenne , and Adrien-Marie Legendre. Interestingly enough Bertrand Russell, an English 20th century mathematician and logician, used Euclid’s work to push mathematics into the next level by explaining to people in his book An Essay On The Foundations Of Geometry [11] how Euclidean Geometry was being replaced by more advanced forms of geometry. Both Russell and Whitehead were co-authored the epoch Principia Mathmatica in which they referenced Euclid a number of times as evidence in their work. Pascal, a 17th century French mathematician, received a copy of Euclid’s Elements as a boy and before the age of 13 he had proven the 32nd proposition of Euclid and discovered a flaw in Rene Descartes geometry [25]. Mersenne, also a 17th century French mathematician, used Euclid’s proof on prime numbers to develop his own

ways or “ forms” as they are called, making it even easier to find large prime numbers. Prime numbers are important to modern day society because they are used in cryptographic software security systems. Basically, large prime numbers can be implemented into coding schemes that are difficult to break. Legendre, a 19th century French mathematician, wrote his most famous book Eléments de Géométrie based entirely off of The Elements. In it he sought to simplify Euclid’s propositions even further. Eléments de Géométrie was used in elementary school classrooms for over a 100 years. [13][24][6]

Euclid influenced politicians such as Abraham Lincoln. Lincoln, as a lawyer traveling on horseback would carry a copy of Euclid’s Elements in his saddlebag. According to his law partner, at night Lincoln would lay on the floor for hours at night studying Euclid’s Elements by lamplight. [5] He was a great admirer of the logical delivery of information that The Elements contained and used Euclid’s systematic approach in many of his speeches. It is no coincidence that the phrase “ dedicated to the proposition” bears such striking similarities to Euclid’s axioms. Lincoln, speaking of his study of Euclid, said,

“ In the course of my law reading I constantly came upon the word ‘ demonstrate’. I thought at first that I understood its meaning, but soon became satisfied that I did not. I said to myself, What do I do when I demonstrate more than when I reason or prove? How does demonstration differ from any other proof?

I consulted Webster’s Dictionary. They told of ‘ certain proof,’ ‘ proof beyond the possibility of doubt’; but I could form no idea of what sort of proof that

was. I thought a great many things were proved beyond the possibility of doubt, without recourse to any such extraordinary process of reasoning as I understood demonstration to be. I consulted all the dictionaries and books of reference I could find, but with no better results. You might as well have defined blue to a blind man.

At last I said,- Lincoln, you never can make a lawyer if you do not understand what demonstrate means; and I left my situation in Springfield, went home to my father's house, and stayed there till I could give any proposition in the six books of Euclid at sight. I then found out what demonstrate means, and went back to my law studies." [1][5]

The astronomers Johannes Kepler and Nicolaus Copernicus were also influenced by Euclid's work. When it came to Kepler's approach to astronomy he depended almost entirely on Euclid. Kepler, much like Galileo studied Euclid while attending a university (Tübingen). Kepler was a devout Lutheran and considered Euclid geometry to be the only geometry that could be applied to the heavens and refused to use any other form of geometry because he considered such forms to be heretical. He developed a proof of concerning planetary motion based entirely off propositions found in The Elements [22]. Copernicus used Euclid's work on optics as evidence in his book On The Revolutions Of The Celestial Spheres which was considered the " starting point of modern astronomy and the defining epiphany that began the scientific revolution".

All these great men of science were not able to use Euclid's work as evidence simply because he was well known or famous for doing something

exciting and spectacular. It was the intellectual quality of Euclid’s work that made the difference. We don’t know enough about Euclid to either love him nor hate him and unless you happen to be a mathematician, his work is undoubtedly not awe inspiring. Nevertheless, Euclid still managed to affect some of the most important figures of the Scientific Revolution by setting the foundations necessary for the development of modern science.

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