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MATHEMATICS AS AN AGENT OF DIALOGUE IN THE SOCIETY

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Abstract: Though Mathematics is mostly considered as a subject of the intelligent, it is used by everybody for daily activities. It acts as an efficient agent of dialogue in the society. Its role in transferring abstract knowledge to concrete experience, in interpreting the unknown and as a tool for problem-solving are discussed in this paper. Mathematics also helps human beings to transcend from concrete experience to abstract knowledge. This paper showcases various elements of Mathematics over a wide spectrum, from those useful in everyday life of human beings to the discussions on potential and actual infinity. Mathematics is an integral part of human life and an essential tool in knowing the universe. We do not deliberately side with any of the schools in Mathematics or that of Philosophy.

Keywords: Abstract Mathematics, Dialogue in Mathematics, Infinity, Mathematical Anxiety, Mathematics and Society, Philosophy of Mathematics, Numbers, Practical Mathematics

1. Introduction

We live in an ever-evolving world. The constant change, the evolution, of the world is both physical and conceptual. To understand the world and to control it, there are always human beings who have inflated hopes on and who hope for mystical or magical short-cuts. Such people probably avoid a possible dialogue with the world in search for knowing it. On the contrary, there are people who use accurate methods of Mathematics and empirical enquiry. This helped the

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development of science. Although Mathematical methods are claimed to be objective, there is an element of unsociableness surrounding it. The incident we narrate next is one such case.

On 7 May 2016, *The Guardian* reported the news about the delaying of an American Airlines flight due to the terror alert by a passenger.[1] Guido Menzio, an economist from the University of Pennsylvania was solving a differential equation that evoked suspicion in the seatmate that led to the delay. It was not a fake or fun news as many American newspapers carried the same item on the very next day, in different magnitudes. Catherine Rampell of *The Washington Post* rounds up the description of the event by saying, "that in America today, the only thing more terrifying than foreigners is … math."[2] This might not be the problem in America alone. However, Mathematics as a terrifying thing is to be really addressed. We look seriously in to the role of Mathematics plays in the society. Quite often, knowledge about and of things can change the perception of it as it is the tool by which the rise and promise of science is to be understood.

We can see that terror and dialogue do not go together. Hence, even if it is a terrifying thing, we explore the areas where Mathematics invites everyone for a dialogue and is involved in dialogues in the society. In itself, Mathematics is a matter of dialogue and it matters the dialogues in the society. It is a matter of dialogue especially from the point of view of Mathematical Anxiety.[3] When one feels the tension, has apprehension, or has a

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[1]"Professor: Flight was Delayed because My Equations Raised Terror," *The Guardian*, 7 May 2016, <https://www.theguardian.com/us-news/2016/may/07/professor-flight-delay-terrorism-equation-american-airlines> (8 May 2016).

[2]"Ivy League Economist Ethnically Profiled, Interrogated for Doing Math on American Airlines Flight," *The Washington Post*, 7 May 2016, <https://www.washingtonpost.com/news/rampage/wp/2016/05/07/ivy-league-economist-interrogated-for-doing-math-on-american-airlines-flight/?utm_term=.c6c6ee8fa8ba> (8 May 2016).

[3]Mark H. Ashcraft, "Math Anxiety: Personal, Educational, and Cognitive Consequences," *Current Directions in Psychological Science* 11, 5 (2002), 181-185.

fear that interferes with math performance, Ashcraft states that one has Mathematical Anxiety. Therefore, as in the case of any other anxiety, a dialogical intervention by experts in the field is unavoidable. We leave this matter to the psychologists.

We begin with a brief analysis of the dialogical aspect of Mathematics. We then move to the discussion on numbers that are part and parcel of daily human life. There is an inseparable bond between Mathematics and logic. Many believe that entire Greek logic is modelled on Mathematics and on the other hand logicians and philosophers argue that Mathematics is reducible to logic. In the next two sections we see the role of Mathematics in reasoning and problem solving. Exploring the Mathematical universe is the task done in the next section. Numbers have a greater role to play than counting. Hence, it will be worth checking also how some of the abstract philosophical concepts such as nothingness, fullness, equality, equivalence, finiteness, infinity etc. can be addressed with the help of Mathematical ideations. In the final section, we invite the readers to enjoy Mathematics to employ it by dialoguing with it.

2. Mathematics Matters the Dialogues in the Society

"Dialogue is a human phenomenon showing how we live, move, and have our being. Dialogues are practices that take place within the streams of life. They serve as the preferred and natural means of living together in harmony and community living."[4] Mathematics is an agent of dialogues in the society for a harmonious and communitarian living. A mathematician, like a painter or a poet, makes patterns and his patterns are more permanent than theirs, because they are made with *ideas*.[5] There are several ways in which Mathematics acts an agent of dialogue.

Thagard defines Cognitive Science as an interdisciplinary activity concerned with thinking and intelligence involving philosophy, psychology, artificial intelligence, neuroscience,

[4]Jose Nandhikkara, "Being Human Dialogically," *Journal of Dharma* 42, 1 (2017), 3-8.

[5]Godfrey Harold Hardy, *A Mathematician's Apology*, Cambridge: Cambridge University Press, 1992.

linguistics and anthropology.[6] One of the branches of Cognitive Science is Numerical Cognition. Although comparative studies[7] hint that some animals have an approximate sense of numbers, there exists apparently no evidence to suggest that non-human beings use numbers as human beings do. From the usefulness angle of numbers the dialogical nature of Mathematics has significance. However, we need to be cautious when we use the term 'useful'. The famous British mathematician G. H. Hardy, warns: "We have concluded that the trivial mathematics is, on the whole, useful, and that the real mathematics, on the whole, is not."[8] Hardy and many other mathematicians did not want Mathematics to be subdued to the realm of what is 'useful' and what is 'practical'. There are plenty of areas in Mathematics that are useful for everyone. At the same time, there exists a greater part of Mathematical areas where one cannot find an instant use. Mathematics is something like a multi-storeyed shop in a supermarket. In the lower floors of it we get things that are needed and useful for the majority. As and when we ascend to the higher levels, we see various levels of Mathematics itself, that may not be 'useful' for the majority in this world.

One of the major purposes of every dialogue is harmony. However, a dialogue need not commence because of disharmony or disconnectedness. Dialogue can facilitate a harmonious state to continue in its uniform path. On the other hand, in most cases, dialogue is to be initiated when there is confusion or disharmony. Dialogue drives out the confusion that emanates from the unknown, or from the unintelligible and augments the partners to the level of cognition. Mathematics, in its essence, is a tool to decipher the ciphered truth that is mostly logical and physical. It converts truths to symbols and then

[6]Paul Thagard, *Mind: Introduction to Cognitive Science*, Vol. 4. Cambridge, MA: MIT Press, 1996.

[7]Christian Agrillo, et al., "Evidence for Two Numerical Systems that are Similar in Humans and Guppies," *PLoS One* 7, 2 (2012), e31923; Culum Brown, "Fish Intelligence, Sentience and Ethics," *Animal Cognition* 18, 1 (2015), 1-17.

[8]Hardy, *A Mathematician's Apology*, 28.

transfers the truths as symbols to the human intellect. An example is the existence of various number systems and their roles in the society. In the next section, we examine the concepts of numbers and some of the roles played by the numbers in the society.

3. Mathematics of Numbers

A major construct of Mathematics is the concept of numbers. Number sense is as good as having rationality. Many think that one who is not good in number is not good in Mathematics. Mathematics is not just the numbers alone. However, historical Mathematics begins with numbers and it is expressed mostly with numbers that eventually is the representation of quantity. Human need for quantification led to the invention of the symbols called numbers. These symbols are representing the measure or multiplicity of the quantity but not the quantified in most cases. A number (or a mathematical equation) is the same written in red or green.[9] Numbers transfer what were intended of them. It is a matter of wonder for anyone to explore the capacity and usefulness of human beings to communicate among themselves about money, time, distance, etc. ignoring numbers. Numbers provide accuracy and precision to money, time and distance beyond any other verbal or nonverbal communication methods. Of course, numbers then come under the verbal communication system to assist human dialogue.

3.1. Time, Speed and Numbers

Time is an intriguing philosophical concept. We live in time. Our ancestors lived in time. Our descendants will live in time. But, how will we connect with the yesterday, the now and the tomorrow? The days and the nights, the weeks and the months, the years and the centuries, etc. find grounding when represented in terms of numbers. From a world of accidents and observations came the numerical representation of time. Thus, Usain Bolt racing past at 10.4 meter per second and a bullet train travels at 167.5 meter per second are quite intelligible for us.

[9]Vikram Seth, *A Suitable Boy*, New York: Harper Collins, 1993.

Numbers give us better comparison of certain items considered in a particular frame. Though numbers convey what was supposed to be conveyed, one must not reach a conclusion that they convey everything of everything. The same Usain Bolt racing past at 10.4 meter per second at the ages of 20, 30, 40 and 50 would definitely convey many things more than his speed.

A related idea is the representation of speed for drivers. On the road, a board that displays (20), (30) and (40) have significant differences. A licensed driver interprets such symbols quickly and adheres to it. Quintessential to being a driver is the understanding of the numbers on the signboards, speedometer, fuel indicator, etc.

3.2 Numbers and Quality of Life

If the average normal oral temperature is higher than 98.6°F (37°C), one needs to be cautious. The normal blood sugar levels for the majority of healthy individuals lie between 72 to 108 mg / dL when fasting and up to 140 mg / dL, 2 hours after eating.[10] The blood pressure reading is ideal and healthy if it is more than 90 over 60 (90 / 60) and less than 120 over 80 (120 / 80).[11] The top number is the *systoli*c blood pressure (The highest pressure when the heart beats and pushes the blood round the body). The bottom one is the *diastolic* blood pressure (The lowest pressure when the heart relaxes between beats). A systematic method of counting the pulse rate was first proposed by a versatile mathematician Nichols of Cusa (1401-1464). He proposed to compare the rate of pulses by weighing the quantity of water run out of a water clock while the pulse beat one hundred times.[12] These are a couple of examples where numbers play a great role in communicating

[10]Diabetes.co.uk, "Blood Sugar Level Ranges," <http: / / www.diabetes.co.uk / diabetes_care / blood-sugar-level-ranges.html> (2 Dec. 2016).

[11]Bloodpressureuk.org, "Blood Pressure Chart"<http: / / www.bloodpressureuk.org / BloodPressureandyou / Thebasics / Bloodpressurechart> (2 Dec. 2016)

[12]Norman Moore, *The History of the Study of Medicine in the British Isles: The Fitz-Patrick Lectures for 1905-6, Delivered Before the Royal College of Physicians of London*, Oxford: Clarendon Press, 1908.

with the society what is hidden. Of course, measures of diabetes, blood pressure and heartbeats are part of 'useful' Mathematics. There is plenty of Mathematics associated with circadian rhythm, describing diets, measuring what is eaten, understanding public health advice about balanced diets, as well as understanding and using nutritional information on packaged foods.[13] Most of these are expressed in numbers. Numbers, thus, are instruments of dialogue by enhancing the ease of interpreting and indicating things that improve the quality of life.

4. Mathematics for Reasoning

Many believe that Mathematics is the study of anything that has a reason as it explores the 'how', 'why' and 'what' of things. This is achieved chiefly by recognizing patterns and contributing suggestions for its repetition and improvement. In establishing the claims of what is right and what is true, mathematicians use a rigorous technique called 'Proof'. In fact, everyone with rationality does proving, in many different ways. Hence, in general everyone is a mathematician. However, academic mathematicians do more documented proving.

The age old concept about of human beings is that they are rational beings. Human beings are thinking beings. The Cartesian phrase, *cogito ergo sum*,[14] is probably the best description of human being as a rational being. This is because of the condition that the existence of human being is recognized by the thinking process. The rationality of human beings is best understood in the realm of Mathematics. Mathematicians observe things that are numerical and non-numerical. According to Norman Biggs, "mathematicians formulate *statements*. Usually the statements are about *numbers*. The statements may be *true* or *false*. To decide whether a statement is true or false requires a

[13]K. E. M. P. Marian, "Making Connections between School Mathematics and the Everyday World: The Example of Health," *Reasoning, Communication and Connections in Mathematics: Yearbook 2012, Association of Mathematics Educators* (2012), 289.

[14]René Descartes, *The Principles of Philosophy*, Munich: BookRix, 2016.

*proo*f."[15] Proof is a powerful display of reason. As Biggs hints, Mathematics helps human beings to sharpen their skills of proof. Major components of recruitments by multinational companies as well as domestic corporates including governmental agencies include logical reasoning and numerical skills.

There is no doubt that reasoning is natural to human beings. Nevertheless, there are varied degrees of the use of reasoning by different human beings. By training one can sharpen the power of reasoning. The classic by Euclid, *The Elements*, gives numerous examples of proofs that can sharpen the power of reasoning. Logic was the foundation of Euclidian Mathematics. Euclid's proof for the number of prime numbers is the most fitting example of how one can deal with situations that are beyond the control of imperfect intellect. Many of the geometrical problems and proofs given by Euclid naturally train and sharpen human intellect, and improve intelligent human communication.

In his *Critique of Pure Reason*, Immanuel Kant admitted three faculties as sources of human knowledge—sensibility, understanding or intellect and reason. For Kant, mathematical objects are the results of human constructions.[16] Kant wrote: "Cognition from principles is that cognition in which I cognise the particular in the general by means of conceptions."[17] The traversal between concept and object is best explained through the medium of Mathematics. In the case of time and speed, we see this traversal explicitly. Hence, the role and necessity of reasoning is strongly articulated through Mathematics.

Among the many capacities human beings have, the most important one is the faculty of reason. The faculty of reason is the reason for human beings to search for truth. Human beings, in general, are in the incessant search for truth. Some search for

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[15]Norman L. Biggs, *Discrete Mathematics*, Oxford: Oxford University Press, 2015.

[16]Amita Chatterjee, "Roads to Mathematical Pluralism: Some Pointers," *Journal of Indian Council of Philosophical Research* 34, 2 (2017), 209-225.

[17]Immanuel Kant, "*Critique of Pure Reason* 1781," *Modern Classical Philosophers*, Cambridge, MA: Houghton Mifflin (1908), 370-456.

the truth of life; others search for the truth of the nature; and some others search for the truth of the truth itself. This search for truth is the basis of recording and documentation. Documentation is the backbone of all the developments in the world. As human beings change their styles and modes of living, a continuous progress is visible in the world. It is by encountering and polishing the truths of the nature, the truths of the truths, that the human beings progress towards better life in their societal living and material assessments. In this pursuit of progress, the most important and precise recording is in the form of Mathematics.

5. Mathematics as a Problem Solver

"Mathematics consists of content and know-how. What is know-how in mathematics? The ability to solve problems."[18] Mathematics as a discipline existed before the development of written languages. One difference between natural language and the language of mathematics is the degree of precision required in communication. In many situations, small errors in the use of natural language do not destroy the overall correctness or effectiveness of a communication.[19] The primary purpose of every natural language is to build the relationship between the individuals. Indirectly, it solves the problems among the parties involved. Mathematics as a problem solver is far beyond the problems among the individuals. The problems between the individuals and the nature and the problems among the natural realities are the clients of human beings.

How does one get away from the spread of disease? How does one communicate with someone who is at a very long distance? How do you sense that the world becomes smaller every day? How does one understand the movements of the celestial bodies? Beyond the puzzles and riddles, Mathematics

[18]George Polya, *How to Solve It: A New Aspect of Mathematical Method*, New Jersey: Princeton University Press, 2014.

[19]IAE-Pedia, "Communicating in the Language of Mathematics," <http://iae-pedia.org/Communicating_in_the_Language_of_Mathematics> (20 Sep. 2016)

has contributed extensively to the problems at micro and macro levels. For example, when the Germans deployed marines with bombs in various parts of the Atlantic and used them with the help of Enigma machine, Alan Turing with his mathematical brilliance, created a machine that could counter the advantages. On the one hand, Einstein's discoveries lead to the creation of nuclear bombs and on the other hand, his predictions could help track the gravitational waves.[20] Detecting and analyzing the information carried by gravitational waves will allow us to observe the Universe in a way never before possible.[21] Thus, Mathematics helps us to understand human beings themselves, everything they involved in and everything they are involved in. This justifies one of the primary purposes of dialogue, *verstand* (understanding).

6. Mathematical Universe

Mathematics speaks about the universe human beings live. Human beings are not the only living beings. Nicholas of Cusa proposed the idea of various dimensions. Much before the Copernicus proposition, Cusa articulated that the earth moves and so does every other body in the universe. His universe, though he sometimes calls it infinite, is simply a universe without assignable limits; and he comes remarkably near, though he does not actually arrive at, the description of the whole, by modern physical relativists, as "finite but

[20]Albert Einstein and Nathan Rosen, "On Gravitational Waves," *Journal of the Franklin Institute* 223, 1 (1937), 43-54.

[21]Gravitational waves are 'ripples' in the fabric of space-time caused by some of the most violent and energetic processes in the Universe. Albert Einstein predicted the existence of gravitational waves in 1916 in his general theory of relativity. Einstein's mathematics showed that massive accelerating objects (such as neutron stars or black holes orbiting each other) would disrupt space-time in such a way that 'waves' of distorted space would radiate from the source (like the movement of waves away from a stone thrown into a pond). Furthermore, these ripples would travel at the speed of light through the Universe, carrying with them information about their cataclysmic origins, as well as invaluable clues to the nature of gravity itself.

unbounded."[22] For Nicholas of Cusa there are many celestial bodies like that of earth and there are nobler creatures other than human beings. However, Descartes has a better way to communicate. The Cartesian dimensional system is a pure mathematical system of understanding different layers of lives. Let us look into the three types of lives, viz., plants, animals and human beings.

Among the three types of living beings, human beings and animals are superior to plants because of their capacity to change their positions in the face of threats and sometimes for comfort. Hence, we may say that plants live in the first dimension. Human beings are superior to animals because of their capacity to change their positions in thinking. Though animals think, their thinking is a very static thinking. Hence, we may say that animals live in the second dimension. Static thinking directs them to live according their instinct. Human beings live in the third dimension. They live, move, remember the past and envision the future.

What is there beyond three dimensions? Mathematics takes one to construct the systems of higher dimensions, including space-time and beyond.

7. Mathematics of the Unknown

In any philosophical branch a good amount of work is dedicated on the Unknown (*Unbekannte*). As the unknown remains ἀγνωστος for an unknown period of time, the rational beings never stop trying to wrest control over it. The search for celestial beings, the forces that control nature, the search for other universes, the quest for the gravitational waves etc. have its inspiration from the mathematical constructs.

7.1. Nothingness *vs* Fullness and Equality *vs* Equivalence

We now see the things that do not exist. The Unknown also is something like nothingness. Both are, however, independently big challenges in the rational process. Nothingness exists everywhere. This is typically, the Mathematical position on

[22]Thomas Whittaker, "Nicholas of Cusa," *Mind* 34, 136 (1925), 436-454.

nothingness. It is an obvious contradiction as existence presupposes something. Hence, to answer the Mathematical position, we need to attack the everywhere existence of nothingness from different perspectives. We note here that 'nothingness exists everywhere' is not same as 'nothingness is everything'. The argument goes like this. Existence guarantees availability, comparability, provability, etc. Set theory in Mathematics comes to the rescue of the above argument. If every element of a set is in another set then we say that it is a subset of that set. Equivalently, we argue that if there exists an element in a set that is not in another set, then it cannot be the subset of that set. Suppose that we keep removing elements from a set. At every stage of the removal of the elements the reduced set is a subset of the original set. Once, when we remove all the elements in that, the set is called an *empty set*. However, at each stage and at the emptiness, we cannot show an element in the reduced set, an element that is not in the original set. This summarises the argument. We remove the string 'set' attached to the above argument. If we use addition and subtraction, we can have analogous argument. Hence, nothingness in Mathematics is something that is available in everything!

Fullness in Mathematics is a relative concept. A set is full in itself. In comparison with other sets, it becomes incomplete. For example, the set of all even numbers is full in itself. But, in comparison with the set of all integers, it is just a part of it. The fullness is now nearly half. Are we sure, it is the half of all the integers? Yes and No. Yes, because for every two adjacent integers, one is even and the other is odd. Hence, the set of even numbers is precisely the half of the set of all integers. No, because for every integer, there is a corresponding element in the set of all even integers. We explain this unbelievable behaviour now. Choose any integer and add it to itself. We get an even integer as the sum. Therefore, for every integer we can find a unique correspondence from the set of all even integers. We, then, can say that the set of all integers and set of all even integers are equivalent sets. We are very particular about the term 'equivalence'. We can find numerous equivalence relations

in Mathematics. The idea of equivalence can be extended to comparing things. A coffee mug and a doughnut have structural equivalence. The basic notion of equivalence of two things is the one to one correspondence of the parts of the things we compare. The equivalence of man and woman is the most important among them. Equality is the beyond equivalence. Those which are equal are equivalent whereas the converse is not true. For example, '2+2 is equal to 3+1'. What is on the left hand side is summed to 4 and is the same as what is on the right hand side. However, 'a+b is just equivalent to c+d' as 'a' and 'b' can be corresponded to 'c' and 'd', respectively.

7.2. Finiteness and Infinity

The articulation of nothingness and fullness leads us to other pertinent and interlinking concepts, 'finiteness' and 'infinity'. Anything that is finite has parts which are uniquely representable and are exhaustible by way of counting. This means that finite is finite in number in general. Hence, there are only finite number of human beings in this world. There are only finite number of lions in the forest, even if we may not be able to count them. Finiteness is applicable only that are quantifiable. It is easy now to dig out what infinity is. Rudin defines infinity as that which is not finite.[23] Though it is an easy definition, it challenges human capacity to count. Apparently, the impossibility to count is treated as the reason to define infinity. Hence, the set of all stars is infinite. The set of all molecules is infinite. The set of all apples is finite because, there is a natural number that represents the total number of apples in the world. Anything that is finite is represented by a number. Hence, as far the finiteness is considered, there are no qualitative differences between two finite sets apart from the fact that the one might be less in number than the other. In addition to these, the idea of equivalence, we had seen earlier, guides us to conclude that a finite set is not equivalent to any of its proper subsets.

[23]Walter Rudin, *Principles of Mathematical Analysis*, New York: McGraw-Hill, 1964.

Infinity draws more problems than the idea of infinity. The ideas of infinity of Georg Cantor had tremors of infinite magnitude in the philosophical circles.[24] He partitioned infinity as countable infinity and uncountable infinity. The natural numbers, integers, rational numbers, etc. are countably infinite. On the other hand, all the numbers between any two distinct numbers is uncountably infinite. It is easy to put it like that. However, the definition of uncountable infinity led Cantor being accused as a pantheist. The simplest explanation of the uncountably infinite set is that the elements of such set cannot be corresponded uniquely against all the natural numbers. Although the philosophical world recognized Cantor later, some of the most respectable intellectual giants of his time viz., Henri Poincaré, Leopold Kronecker, Ludwig Wittgenstein, etc. raised serious objections against him and some of them accused him for perverted thinking. This is chiefly because, contrary to their beliefs, the nature of potential and actual infinity can be understood not in terms of transcendental truths, or in terms of formal logic, but in terms of the manipulation of meaningless symbols in human *ideas*, and *human cognitive mechanisms*.[25]

Infinity can be understood in another manner through a limiting process. Dividing a number by another number called a divisor, gives us the count of the divisors in the number being divided. If the value of the divisor is decreased, the outcome becomes larger. For example, 10 when divided by 10, 5, 2 and 1 are 1, 2, 5 and 10, respectively. When 10 is divided by 1/10, 1/100 and 1/1000, we get 100, 1000 and 10000, respectively. Hence, when the divisor is negligibly small, the outcome is enormously large. Therefore, we say that infinity is that which is obtained when a non-zero number is divided by a value very close to zero. To conclude, mathematical construct of finiteness and infinity in many sense is more concrete and approachable.

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[24]Joseph Warren Dauben, *Georg Cantor: His Mathematics and Philosophy of the Infinite*, New Jersey: Princeton University Press, 1990.

[25]Rafael E. Núnez, "Creating Mathematical Infinities: Metaphor, Blending, and the Beauty of Transfinite Cardinals," *Journal of Pragmatics* 37, 10 (2005), 1717-1741.

8. Dialogue within Mathematics

The discussion so far is on how Mathematics works as an agent of dialogue in the society. To effectively use Mathematics as an agent of effective dialogue, one has to have some dialogue within Mathematics itself. This dialogue, in an ordinary level, is that of someone learning a language. The short story "A Day's Wait"[26] by Ernest Hemingway illustrates the need for simple dialogue in Mathematics. The story focuses on a boy who gets flu and his confusion between Fahrenheit and Celsius scales of body temperature, which makes the boy depressed and fearful.

It is not enough that one knows numbers or some mathematical symbols but one should know how to interpret it. In the higher level of Mathematics, a deep dialogue within Mathematics itself is necessary. Mathematicians often use the phrases such as "trivially," "we know that," "without loss of generality," "implies," "hence," and "therefore," to name a few. These and other usages in Mathematics might have to be quite natural to be used effectively. People who use these phrases in their original sense are deeply in dialogue with Mathematics. They are the people who help Mathematics to be an agent of dialogue in the society. In teaching as well as in writing, the effective role of Mathematicians can be identified by checking who are in dialogue with Mathematics itself.

9. Conclusion

The former Lucasian Professor of Mathematics at the University of Cambridge, Paul Dirac, presents beautifully the most important role of Mathematics: "Mathematics is the tool specially suited for dealing with the abstract concepts of any kind and there is no limit to its power in this field."[27] The role of Mathematics as an agent of dialogue in the society is discussed here analysing its various incarnations. Mathematics primarily improves quality in the societal dialogues. The role of numbers in society is second to

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[26]Ernest Hemingway, "A Day's Wait," *The Snows of Kilimanjaro and Other Stories*, New York: Scribner, 1961.

[27]Paul Adrien Maurice Dirac, *The Principles of Quantum Mechanics*, No. 27, Oxford: Oxford University Press, 1930.

none. They improve precision to the dialogues in the society. As a tool for reasoning and problem solving, Mathematics creates its own universe. It has unimaginable power in helping the parties in the dialogues intelligible. The words of Lord Kelvin justifies it: "A single curve, drawn in the manner of the curve of prices of cotton, describes all that the ear can possibly hear as the result of the most complicated musical performance … That to my mind is a most wonderful proof of the potency of mathematics."[28] A powerful communicator of societal values such as liberty, equality and justice, Abraham Lincoln is believed to have studied and nearly mastered the six books of Euclid. Lincoln modelled many of his speeches including the famous Cooper Union speech, after Euclidean geometric proofs. *Euclid's Elements* is a way to improve an individual's ability to think and reason logically. We wind up the discussion by invoking the words of one of the most intelligent human beings ever lived, Albert Einstein. "How can it be that mathematics, being after all a product of human thought which is independent of experience, is so admirably appropriate to the objects of reality?"[29]

The mediator role of Mathematics in societal transactions is evident in the use of concepts such as money, time, speed, distance, etc. with expressions in the form of numbers. The beauty of Mathematics, however, is only partially enjoyable through the utilitarian aspects of Mathematics. Moreover, the dominance of numbers in all forms in human life is not the only dialogical aspect of Mathematics. Mathematical methods are powerful even to communicate the actual infinity. We do not address here positions and concerns of various schools of Mathematics. Such an analysis might go beyond the scope of this tract. Great mathematical 'mystics' of the twentieth century Ludwig Wittgenstein, Simone Weil, Kurt Gödel *et al.* could be read in connection with the dialogue between the world and *Unbekannte*.

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[28]Silvanus P. Thompson, *The Life of Lord Kelvin*, Vol. 2, New York: Chelsea Publishing, 1976.

[29]Albert Einstein, *Ideas and Opinions*, New York: Crown Publishers, 1954.