Implications of the Drake Equation, a Socratic Seminar

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For Middle School, High School, College / Upper Division; Humanities, Mathematics, Science, Social Sciences

SUMMARY:
The Drake Equation relates to many important lessons for students. While the math/science implications are obvious, there are philosophical implications that are also important for students. This Socratic Seminar offers points of departure for critical thinking, debates, writing assignments, and further class discussion. (These points can also be used as lecture notes.)

LEARNING GOALS:
• Discuss and/or write about the talking points for each variable in the equation
• Explore the philosophical implications of the Drake Equation

Introduction:

The Drake Equation is a hypothetical determination of the number of intelligent civilizations in our galaxy capable of communicating with Earth. http://en.wikipedia.org/wiki/Drake_equation

While there is no definitive answer for this equation, the implications of each variable represent valuable philosophical speculations. The Drake Equation can be used for several purposes in various classrooms. In addition to introducing concepts about astronomy, life, intelligence, communication, civilization, and sustainability, it can be used to develop critical thinking, note taking, and classroom conversation skills. The Socratic seminar is the format suggested here.
Socratic seminars on the implications of the variables in the Drake

Equation can be condensed into a single lecture/discussion section or expanded over a number of weeks. The discussions can be geared to a middle school or graduate school audience. The discussions can be in-class or online, verbal or written, informal dialogue or formal research assignments. The discussions can be more sociological or more scientific depending on the goals of the teacher or the student. In any case, it is recommended that students spend time reflecting on (and possibly researching about) the implications and meaning of each point. Written assignments are encouraged.

There are several other sources of information about the Drake Equation, but this one from PBS is interactive, represents good explanations of each variable, and can be projected effectively. Nova | The Drake Equation For math and science classes, it has a tool for changing the value of each variable and coming up with a different result. Interestingly, Frank Drake, the creator of the equation, put in variables that result in almost 10,000 communicating civilizations in the Milky Way. Depending on the instructor's purposes and the age and ability level of the students, this link can be used before or after the Socratic Seminars on each variable.

Directions for a "flipped" lesson:

As a homework assignment, have the students view/use and take notes on the PBS Nova Drake Equation website. They should come into class knowing the basic definitions of each equation. (A worksheet is being developed for this format.) The instructor can review these definitions, but then begins asking questions based on the discussion points below. These discussion points can be expanded upon, and there are many meaningful digressions.

Drake Equation Discussion Points

N - Ask the question: "Do you believe that there is other life in outer space?" There are only two answers: Yes or No, and each one represents

an astonishing reality. If there is life, what is it like, are they like us, etc.? If not, we really are special! In fact, the "no" answer may result in religious notions about humanity. Discuss the probability and implications of each response. N is the answer to the Drake Equation, so after considering the other variables, return to this Number in considering the totality of implications.

R - Ask the question: "What is the difference between a million and billion?" Obvious answers involve the basic math, zeros, and spelling. A way to understand the difference is to count seconds - one, two, three... Doing that, it will take less that two weeks to count to a million, but over 33 years to count to a billion! Discuss implications and other ways of thinking about really big numbers. Consider cells, money, populations. (Related: human heart beats in time, life span, and compared to other animals. The human potential of living to a billion heartbeats almost triples the life expectancy of other mammals. We are special! A healthy heart - beating slowly - one per second. Digression: Baroque music's effect on brainwaves - 60 beats a minute in 4/4 time.)

fp - Ask the question: "Have you ever seen our galaxy, the Milky Way, with your naked eye?" You can, but only on a clear, moonless night far from city lights - it is the swath of stars across the sky seen from within the galaxy. Consider this: one human brain is a speck of dust in city; a city is
a speck of dust on the planet; the planet is a speck of dust in the solar system; our star, the sun, is a speck of dust in the galaxy - but we tiny specks of specks of dust can understand that! Now consider this as you look out at all those stars - they are not the planets that would hold life. The planets are dark. When Frank Drake came up with the Equation, the only known planets were those in our solar system. Since then, others have been identified (how?), and Pluto has been demoted. Is eight or nine average for most stars? Would other heavenly bodies support life? (Dark matter discussion?)

ne - Ask the question: "Is the biosphere around earth like an orange peel or an onion skin?" Consider what a 10-20 mile distance looks like on a

globe (short!), then consider that distance straight up. From the cruising altitude of jets to the depth of most sea life, what is the thickness of the biosphere? The correct answer is an onion skin, thus the fragility of biosphere. Then, present aspects of earth's distance from and angle to the sun, temperatures, atmospheric chemistry, element concentrations, and the conditions necessary for life. Again, our circumstances, our margins, are fine, fragile, and evanescent. (Digression on seasons, latitude & longitude, and environments conducive to life.) Consider, carbon-based v. other element-based life forms. (Related discussions include the symbiosis of plants and animals - the molecular structure of hemoglobin compared to chlorophyll, etc.)

fl - Ask the question: "What is life?" Consider definitions of fire, definitions of viruses v. bacteria, and the fact that we have not created life in a laboratory. Consider creationism v. evolution (chickens & eggs), divine sparks, Frankenstein, etc. Best answer to "What is life?": "That which dies!" Discuss implications of concepts like: "the meaning of life," "the good life," the value of life (to insurance companies, hit men, the US govt., China...?), life goals, etc. Discuss the implications of death, circles of life, afterlife, etc.

fi - Ask the question: "What is intelligence?" Consider the intelligence of cock roaches, dogs, and dolphins compared to humans. Consider brain to body size ratios. Given that, are we smartest (most able to learn) as infants? Consider Dumb v. Stupid (relative cognitive ability v. doing something against one's best interest. Consider Barbara Tuchman's thesis in "The March of Folly," or Steve Allen's in "Dumbth." What is the difference between dumb & stupid? Should education specialist study stupidity v. intelligence? Consider measurements of intelligence, academic testing, Bloom's Taxonomy of the Cognitive Domain. Consider IQ v. Emotional Intelligence and other personality factors necessary for success. For a sophisticated students group, one definition of intelligent creatures - those who have sex for fun! Further considerations: If a dolphin has the same brain to body size ratio and other indicators of high intelligence, why don't they build things? Do they look up at the stars at night and wonder if there is life in outer

space? What kind of intelligence is required to build a radio telescope?

fc - Ask the question: "If humans and dolphins are both smart, why can't we talk to them?" Consider languages and language development in humans, translation of meaning, and of communication in general. Why communicate, with whom, how? How do you communicate with people when you have no language in common? Consider universal languages - mathematical principles, musical notes, the electro-magnetic spectrum, etc. How/what can you communicate with them? (ie. So we and the ETs understand prime numbers, what else?) Consider the evolution of English from before Shakespeare to the present. Consider warning labels on places like Yucca Mountain that will make sense to humans thousands of years from now. Consider communicating at the speed of light with a planet 100+ light years away - turn around time!? What would you say to another world? What questions would you ask them? Will your great, great grandchildren want to know the answers?

L - Ask the question: "How long will we, as an intelligent civilization capable of communicating with other worlds, last? Consider turn around times of correspondence. Consider the fact that Marconi's invention of the radio (our means of communicating) and the development of the atomic bomb (our means of destroying ourselves) was less than 100 years. Consider other civilizations on earth that are no longer with us. How many planets no longer sustain intelligent life? When your little speck-of-dust-self looks up at the billions of stars in the sky, you are looking into the distant past, light from stars thousands and thousands of years ago, long before civilization on earth began. Discuss implications...

A Word about Socratic Seminars

Like the Drake Equation itself, there are no definitive answers to the questions posed above. The point in asking them is to elicit critical thinking, speculation, and debate. The discussion is the point, therefore it is important to have some guidelines or norms for a Socratic seminar.

Students should be respectful, listen carefully, show understanding before rebuttal or refutation, and not dominate the discussion. Having an open mind is desirable, but some students may have strong beliefs or religious convictions that are challenged, and it is advisable that no one be condemned or alienated. One goal of this activity is to sustain wonder and perhaps revitalize students' intellectual curiosity. Here is a useful source for Socratic seminars: http://www.nwabr.org/education/pdfs/PRIMER/PrimerPieces/SocSem.pdf

A Word about Evaluation

While the discussion and perhaps a renewed sense of wonder can be the goal, there are several ways to assess this activity. Collecting and evaluating notes, writing prompts based on each variable, and essays on the implications of the Drake Equation are some obvious assignments.

Teachers may emphasize their subject matter in following up, i.e. related mathematical equations, scientific theories, historical developments, philosophical notions, or hypothetical scenarios can be explored. The discussion itself can be evaluated, in substance or style, individually or as a group.