The Socratic Method:
Teaching by Asking Instead of by Telling

by Rick Garlikov

The following is a transcript of a teaching experiment, using the Socratic method, with a regular third grade class in a suburban elementary school. I present my perspective and views on the session, and on the Socratic method as a teaching tool, following the transcript. The class was conducted on a Friday afternoon beginning at 1:30, late in May, with about two weeks left in the school year. This time was purposely chosen as one of the most difficult times to entice and hold these children's concentration about a somewhat complex intellectual matter. The point was to demonstrate the power of the Socratic method for both teaching and also for getting students involved and excited about the material being taught. There were 22 students in the class. I was told ahead of time by two different teachers (not the classroom teacher) that only a couple of students would be able to understand and follow what I would be presenting. When the class period ended, I and the classroom teacher believed that at least 19 of the 22 students had fully and excitedly participated and absorbed the entire material. The three other students' eyes were glazed over from the very beginning, and they did not seem to be involved in the class at all. The students' answers below are in capital letters.

The experiment was to see whether I could teach these students binary arithmetic (arithmetic using only two numbers, 0 and 1) only by asking them questions. None of them had been introduced to binary arithmetic before. Though the ostensible subject matter was binary arithmetic, my primary interest was to give a demonstration to the teacher of the power and benefit of the Socratic method where it is applicable. That is my interest here as well. I chose binary arithmetic as the vehicle for that because it is something very difficult for children, or anyone, to understand when it is taught normally; and I believe that a demonstration of a method that can teach such a difficult subject easily to children and also capture their enthusiasm about that subject is a very convincing demonstration of the value of the method. (As you will see below, understanding binary arithmetic is also about understanding "place-value" in general. For those who seek a much more detailed explanation about place-value, visit the long paper on The Concept and Teaching of Place-Value.) This was to be the Socratic method in what I consider its purest form, where questions (and only questions) are used to arouse curiosity and at the same time serve as a logical, incremental, step-wise guide that enables students to figure out about a complex topic or issue with their own thinking and insights. In a less pure form, which is normally the way it occurs, students tend to get stuck at some point and need a teacher's explanation of some aspect, or the teacher gets stuck and cannot figure out a question that will get the kind of answer or point desired, or it just becomes more efficient to "tell" what you want to get across. If "telling" does occur, hopefully by that time, the students have been aroused by the questions to a state of curious receptivity to absorb an explanation that might otherwise have been meaningless to them. Many of the questions are decided before the class; but depending on what answers are given, some questions have to be thought up extemporaneously. Sometimes this is very difficult to do, depending on how far from what is anticipated or expected some of the students' answers are. This particular attempt went better than my best possible expectation, and I had much higher expectations than any of the teachers I discussed it with prior to doing it.

I had one prior relationship with this class. About two weeks earlier I had shown three of the third grade classes together how to throw a boomerang and had let each student try it once. They had really enjoyed that. One girl and one boy from the 65 to 70 students had each actually caught their returning boomerang on their throws. That seemed to add to everyone's enjoyment. I had therefore already established a certain rapport with the students, rapport being something that I feel is important for getting them to comfortably and enthusiastically participate in an intellectually uninhibited manner in class and without being psychologically paralyzed by fear of "messing up".

When I got to the classroom for the binary math experiment, students were giving reports on famous people and were dressed up like the people they were describing. The student I came in on was reporting on John Glenn, but he had not mentioned the dramatic and scary problem of that first American trip in orbit. I asked whether anyone knew what really scary thing had happened on John Glenn's flight, and whether they knew what the flight was. Many said a trip to the moon, one thought Mars. I told them it was the first full earth orbit in space for an American. Then someone remembered hearing about something wrong with the heat shield, but didn't remember what. By now they were listening intently. I explained about how a light had come on that indicated the heat shield was loose or defective and that if so, Glenn would be incinerated coming back to earth. But he could not stay up there alive forever and they had nothing to send up to get him with. The engineers finally determined, or hoped, the problem was not with the heat shield, but with the warning light. They thought it was what was defective. Glenn came down. The shield was ok; it had been just the light. They thought that was neat.

"But what I am really here for today is to try an experiment with you. I am the subject of the experiment, not you. I want to see whether I can teach you a whole new kind of arithmetic only by asking you questions. I won't be allowed to tell you anything about it, just ask you things. When you think you know an answer, just call it out. You won't need to raise your hands and wait for me to call on you; that takes too long." [This took them a while to adapt to. They kept raising their hands; though after a while they simply called out the answers while raising their hands.] Here we go.

1) "How many is this?" [I held up ten fingers.]

TEN

2) "Who can write that on the board?" [virtually all hands up; I toss the chalk to one kid and indicate for her to come up and do it]. She writes

10

3) Who can write ten another way? [They hesitate than some hands go up. I toss the chalk to another kid.]

4) Another way?

5) Another way?

2 x 5 [inspired by the last idea]

6) That's very good, but there are lots of things that equal ten, right? [student nods agreement], so I'd rather not get into combinations that equal ten, but just things that represent or sort of mean ten. That will keep us from having a whole bunch of the same kind of thing. Anybody else?

TEN

7) One more?

X [Roman numeral]

8) [I point to the word "ten"]. What is this?

THE WORD TEN

9) What are written words made up of?

LETTERS

10) How many letters are there in the English alphabet?

26

11) How many words can you make out of them?

ZILLIONS

12) [Pointing to the number "10"] What is this way of writing numbers made up of?

NUMERALS

13) How many numerals are there?

NINE / TEN

14) Which, nine or ten?

TEN

15) Starting with zero, what are they? [They call out, I write them in the following way.]

0
1
2
3
4
5
6
7
8
9

16) How many numbers can you make out of these numerals?

MEGA-ZILLIONS, INFINITE, LOTS

17) How come we have ten numerals? Could it be because we have 10 fingers?

COULD BE

18) What if we were aliens with only two fingers? How many numerals might we have?

2

19) How many numbers could we write out of 2 numerals?

NOT MANY /

[one kid:] THERE WOULD BE A PROBLEM

20) What problem?

THEY COULDN'T DO THIS [he holds up seven fingers]

21) [This strikes me as a very quick, intelligent insight I did not expect so suddenly.] But how can you do fifty five?

[he flashes five fingers for an instant and then flashes them again]

22) How does someone know that is not ten? [I am not really happy with my question here but I don't want to get side-tracked by how to logically try to sign numbers without an established convention. I like that he sees the problem and has announced it, though he did it with fingers instead of words, which complicates the issue in a way. When he ponders my question for a second with a "hmmm", I think he sees the problem and I move on, saying...]

23) Well, let's see what they could do. Here's the numerals you wrote down [pointing to the column from 0 to 9] for our ten numerals. If we only have two numerals and do it like this, what numerals would we have.

0, 1

24) Okay, what can we <u>write</u> as we count? [I write as they call out answers.]

0 ZERO
1 ONE
[silence]

25) Is that it? What do we do on this planet when we run out of numerals at 9?

WRITE DOWN "ONE, ZERO"

26) Why?

[almost in unison] I DON'T KNOW; THAT'S JUST THE WAY YOU WRITE "TEN"

27) You have more than one numeral here and you have already used these numerals; how can you use them again?

WE PUT THE 1 IN A DIFFERENT COLUMN

28) What do you call that column you put it in?

TENS

29) Why do you call it that?

DON'T KNOW

30) Well, what does this 1 and this 0 mean when written in these columns?

1 TEN AND NO ONES

31) But why is this a ten? Why is this [pointing] the ten's column?

DON'T KNOW; IT JUST IS!

32) I'll bet there's a reason. What was the first number that needed a new column for you to be able to write it?

TEN

33) Could that be why it is called the ten's column?! What is the first number that needs the next column?

100

34) And what column is that?

HUNDREDS

35) After you write 19, what do you have to change to write down 20?

9 to a 0 and 1 to a 2

36) Meaning then 2 tens and no ones, right, because 2 tens are ___?

TWENTY

37) First number that needs a fourth column?

ONE THOUSAND

38) What column is that?

THOUSANDS

39) Okay, let's go back to our two-fingered aliens arithmetic. We have

0	zero
1	one.

What would we do to write "two" if we did the same thing we do over here [tens] to write the next number after you run out of numerals?

START ANOTHER COLUMN

40) What should we call it?

TWO'S COLUMN?

41) Right! Because the first number we need it for is ___?

TWO

42) So what do we put in the two's column? How many two's are there in two?

1

43) And how many one's extra?

ZERO

44) So then two looks like this: [pointing to "10"], right?

RIGHT, BUT THAT SURE LOOKS LIKE TEN.

45) No, only to you guys, because you were taught it wrong [grin] -- to the aliens it is two. They learn it that way in pre-school just as you learn to call one, zero [pointing to "10"] "ten". But it's not really ten, right? It's two -- if you only had two fingers. How long does it take a little kid in pre-school to learn to read numbers, especially numbers with more than one numeral or column?

TAKES A WHILE

46) Is there anything obvious about calling "one, zero" "ten" or do you have to be taught to call it

"ten" instead of "one, zero"?

HAVE TO BE TAUGHT IT

47) Ok, I'm teaching you different. What is "1, 0" here?

TWO

48) Hard to see it that way, though, right?

RIGHT

49) Try to get used to it; the alien children do. What number comes next?

THREE

50) How do we write it with our numerals?

We need one "TWO" and a "ONE"

[I write down 11 for them] So we have

0	**zero**
1	**one**
10	**two**
11	**three**

51) Uh oh, now we're out of numerals again. How do we get to four?

START A NEW COLUMN!

52) Call it what?

THE FOUR'S COLUMN

53) Call it out to me; what do I write?

ONE, ZERO, ZERO

[I write "100 four" under the other numbers]

54) Next?

ONE, ZERO, ONE

I write "101 five"

55) Now let's add one more to it to get six. But be careful. [I point to the 1 in the one's column and ask] If we add 1 to 1, we can't write "2", we can only write zero in this column, so we need to carry ____?

ONE

56) And we get?

ONE, ONE, ZERO

57) Why is this six? What is it made of? [I point to columns, which I had been labeling at the top

with the word "one", "two", and "four" as they had called out the names of them.]

a "FOUR" and a "TWO"

58) Which is ____?

SIX

59) Next? Seven?

ONE, ONE, ONE

I write "111 seven"

60) Out of numerals again. Eight?

NEW COLUMN; ONE, ZERO, ZERO, ZERO

I write "1000 eight"

[We do a couple more and I continue to write them one under the other with the word next to each number, so we have:]

0	zero
1	one
10	two
11	three
100	four
101	five
110	six
111	seven
1000	eight
1001	nine
1010	ten

61) So now, how many numbers do you think you can write with a one and a zero?

MEGA-ZILLIONS ALSO/ ALL OF THEM

62) Now, let's look at something. [Point to Roman numeral X that one kid had written on the board.] Could you easily multiply Roman numerals? Like MCXVII times LXXV?

NO

63) Let's see what happens if we try to multiply in alien here. Let's try two times three and you multiply just like you do in tens [in the "traditional" American style of writing out multiplication].

10	two
x 11	times three

They call out the "one, zero" for just below the line, and "one, zero, zero" for just below that and so I write:

10	two
x 11	times three
10	
100	

110

64) Ok, look on the list of numbers, up here [pointing to the "chart" where I have written down the numbers in numeral and word form] what is 110?

SIX

65) And how much is two times three in real life?

SIX

66) So alien arithmetic works just as well as your arithmetic, huh?

LOOKS LIKE IT

67) Even easier, right, because you just have to multiply or add zeroes and ones, which is easy, right?

YES!

68) There, now you know how to do it. Of course, until you get used to reading numbers this way, you need your chart, because it is hard to read something like "10011001011" in alien, right?

RIGHT

69) So who uses this stuff?

NOBODY/ ALIENS

70) No, I think you guys use this stuff every day. When do you use it?

NO WE DON'T

71) Yes you do. Any ideas where?

NO

72) [I walk over to the light switch and, pointing to it, ask:] What is this?

A SWITCH

73) [I flip it off and on a few times.] How many positions does it have?

TWO

74) What could you call these positions?

ON AND OFF/ UP AND DOWN

75) If you were going to give them numbers what would you call them?

ONE AND TWO/

[one student] OH!! ZERO AND ONE!

[other kids then:] OH, YEAH!

76) You got that right. I am going to end my experiment part here and just tell you this last part.

Computers and calculators have lots of circuits through essentially on/off switches, where one way represents 0 and the other way, 1. Electricity can go through these switches really fast and flip them on or off, depending on the calculation you are doing. Then, at the end, it translates the strings of zeroes and ones back into numbers or letters, so we humans, who can't read long strings of zeroes and ones very well can know what the answers are.

[at this point one of the kid's in the back yelled out, OH! NEEEAT!!]

I don't know exactly how these circuits work; so if your teacher ever gets some electronics engineer to come into talk to you, I want you to ask him what kind of circuit makes multiplication or alphabetical order, and so on. And I want you to invite me to sit in on the class with you.

Now, I have to tell you guys, I think you were leading me on about not knowing any of this stuff. You knew it all before we started, because I didn't tell you anything about this -- which by the way is called "binary arithmetic", "bi" meaning two like in "bicycle". I just asked you questions and you knew all the answers. You've studied this before, haven't you?

NO, WE HAVEN'T. REALLY.

Then how did you do this? You must be amazing. By the way, some of you may want to try it with other sets of numerals. You might try three numerals 0, 1, and 2. Or five numerals. Or you might even try twelve 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, ~, and ^ -- see, you have to make up two new numerals to do twelve, because we are used to only ten. Then you can check your system by doing multiplication or addition, etc. Good luck.

After the part about John Glenn, the whole class took only 25 minutes.

Their teacher told me later that after I left the children talked about it until it was time to go home.

. . . .

My Views About This Whole Episode

Students do not get bored or lose concentration if they are actively participating. Almost all of these children participated the whole time; often calling out in unison or one after another. If necessary, I could have asked if anyone thought some answer might be wrong, or if anyone agreed with a particular answer. You get extra mileage out of a given question that way. I did not have to do that here. Their answers were almost all immediate and very good. If necessary, you can also call on particular students; if they don't know, other students will bail them out. Calling on someone in a non-threatening way tends to activate others who might otherwise remain silent. That was not a problem with these kids. Remember, this was not a "gifted" class. It was a normal suburban third grade of whom two teachers had said only a few students would be able to understand the ideas.

The topic was "twos", but I think they learned just as much about the "tens" they had been using and not really understanding.

This method takes a lot of energy and concentration when you are doing it fast, the way I like to do it when beginning a new topic. A teacher cannot do this for every topic or all day long, at least not the first time one teaches particular topics this way. It takes a lot of preparation, and a lot of thought. When it goes well, as this did, it is so exciting for both the students and the teacher that it is difficult to stay at that peak and pace or to change gears or topics. When it does not go as well, it is very taxing trying to figure out what you need to modify or what you need to say. I practiced this particular sequence of questioning a little bit one time with a first grade teacher. I found a flaw in my sequence of questions. I had to figure out how to correct that. I had time to prepare this

particular lesson; I am not a teacher but a volunteer; and I am not a mathematician. I came to the school just to do this topic that one period.

I did this fast. I personally like to do new topics fast originally and then re-visit them periodically at a more leisurely pace as you get to other ideas or circumstances that apply to, or make use of, them. As you re-visit, you fine tune.

The chief benefits of this method are that it excites students' curiosity and arouses their thinking, rather than stifling it. It also makes teaching more interesting, because most of the time, you learn more from the students -- or by what they make you think of -- than what you knew going into the class. Each group of students is just enough different, that it makes it stimulating. It is a very efficient teaching method, because the first time through tends to cover the topic very thoroughly, in terms of their understanding it. It is more efficient for their learning then lecturing to them is, though, of course, a teacher can lecture in less time.

It gives constant feed-back and thus allows monitoring of the students' understanding as you go. So you know what problems and misunderstandings or lack of understandings you need to address as you are presenting the material. You do not need to wait to give a quiz or exam; the whole thing is one big quiz as you go, though a quiz whose point is teaching, not grading. Though, to repeat, this is teaching by stimulating students' thinking in certain focused areas, in order to draw ideas out of them; it is not "teaching" by pushing ideas into students that they may or may not be able to absorb or assimilate. Further, by quizzing and monitoring their understanding as you go along, you have the time and opportunity to correct misunderstandings or someone's being lost at the immediate time, not at the end of six weeks when it is usually too late to try to "go back" over the material. And in some cases their ideas will jump ahead to new material so that you can meaningfully talk about some of it "out of (your!) order" (but in an order relevant to them). Or you can tell them you will get to exactly that in a little while, and will answer their question then. Or suggest they might want to think about it between now and then to see whether they can figure it out for themselves first. There are all kinds of options, but at least you know the material is "live" for them, which it is not always when you are lecturing or just telling them things or they are passively and dutifully reading or doing worksheets or listening without thinking.

If you can get the right questions in the right sequence, kids in the whole intellectual spectrum in a normal class can go at about the same pace without being bored; and they can "feed off" each others' answers. Gifted kids may have additional insights they may or may not share at the time, but will tend to reflect on later. This brings up the issue of teacher expectations. From what I have read about the supposed sin of tracking, one of the main complaints is that the students who are not in the "top" group have lower expectations of themselves and they get teachers who expect little of them, and who teach them in boring ways because of it. So tracking becomes a self-fulfilling prophecy about a kid's educability; it becomes dooming. That is a problem, not with tracking as such, but with teacher expectations of students (and their ability to teach). These kids were not tracked, and yet they would never have been exposed to anything like this by most of the teachers in that school, because most felt the way the two did whose expectations I reported. Most felt the kids would not be capable enough and certainly not in the afternoon, on a Friday near the end of the school year yet. One of the problems with not tracking is that many teachers have almost as low expectations of, and plans for, students grouped heterogeneously as they do with non-high-end tracked students. The point is to try to stimulate and challenge all students as much as possible. The Socratic method is an excellent way to do that. It works for any topics or any parts of topics that have any logical natures at all. It does not work for unrelated facts or for explaining conventions, such as the sounds of letters or the capitals of states whose capitals are more the result of historical accident than logical selection.

Of course, you will notice these questions are very specific, and as logically leading as possible. That is part of the point of the method. Not just any question will do, particularly not broad, very open ended questions, like "What is arithmetic?" or "How would you design an arithmetic with only two numbers?" (or if you are trying to teach them about why tall trees do not fall over when

the wind blows "what is a tree?"). Students have nothing in particular to focus on when you ask such questions, and few come up with any sort of interesting answer.

And it forces the teacher to think about the logic of a topic, and how to make it most easily assimilated. In tandem with that, the teacher has to try to understand at what level the students are, and what prior knowledge they may have that will help them assimilate what the teacher wants them to learn. It emphasizes student understanding, rather than teacher presentation; student intake, interpretation, and "construction", rather than teacher output. And the point of education is that the students are helped most efficiently to learn by a teacher, not that a teacher make the finest apparent presentation, regardless of what students might be learning, or not learning. I was fortunate in this class that students already understood the difference between numbers and numerals, or I would have had to teach that by questions also. And it was an added help that they had already learned Roman numerals. It was also most fortunate that these students did not take very many, if any, wrong turns or have any firmly entrenched erroneous ideas that would have taken much effort to show to be mistaken.

I took a shortcut in question 15 although I did not have to; but I did it because I thought their answers to questions 13 and 14 showed an understanding that "0" was a numeral, and I didn't want to spend time in this particular lesson trying to get them to see where "0" best fit with regard to order. If they had said there were only nine numerals and said they were 1-9, then you could ask how they could write ten numerically using only those nine, and they would quickly come to see they needed to add "0" to their list of numerals.

These are the four critical points about the questions: 1) they must be interesting or intriguing to the students; they must lead by 2) incremental and 3) logical steps (from the students' prior knowledge or understanding) in order to be readily answered and, at some point, seen to be evidence toward a conclusion, not just individual, isolated points; and 4) they must be designed to get the student to see particular points. You are essentially trying to get students to use their own logic and therefore see, by their own reflections on your questions, either the good new ideas or the obviously erroneous ideas that are the consequences of their established ideas, knowledge, or beliefs. Therefore you have to know or to be able to find out what the students' ideas and beliefs are. You cannot ask just any question or start just anywhere.

It is crucial to understand the difference between "logically" leading questions and "psychologically" leading questions. Logically leading questions require understanding of the concepts and principles involved in order to be answered correctly; psychologically leading questions can be answered by students' keying in on clues other than the logic of the content. Question 39 above is psychologically leading, since I did not want to cover in *this* lesson the concept of value-representation but just wanted to use "columnar-place" value, so I psychologically led them into saying "Start another column" rather than getting them to see the reasoning behind columnar-place as merely one form of value representation. I wanted them to see how to use columnar-place value logically without trying *here* to get them to totally understand *its* logic. (A common form of value-representation that is not "place" value is color value in poker chips, where colors determine the value of the individual chips in ways similar to how columnar place does it in writing. For example if white chips are worth "one" unit and blue chips are worth "ten" units, 4 blue chips and 3 white chips is the same value as a "4" written in the "tens" column and a "3" written in the "ones" column for almost the same reasons.)

For the Socratic method to work as a teaching tool and not just as a magic trick to get kids to give right answers with no real understanding, it is crucial that the important questions in the sequence must be logically leading rather than psychologically leading. There is no magic formula for doing this, but one of the tests for determining whether you have likely done it is to try to see whether leaving out some key steps still allows people to give correct answers to things they are not likely to really understand. Further, in the case of binary numbers, I found that when you used this sequence of questions with impatient or math-phobic adults who didn't want to have to think but just wanted you to "get to the point", they could not correctly answer very far into even the

above sequence. That leads me to believe that answering most of these questions correctly, requires understandingof the topic rather than picking up some "external" sorts of clues in order to just guess correctly. Plus, generally when one uses the Socratic method, it tends to become pretty clear when people get lost and are either mistaken or just guessing. Their demeanor tends to change when they are guessing, and they answer with a questioning tone in their voice. Further, when they are logically understanding as they go, they tend to say out loud insights they have or reasons they have for their answers. When they are just guessing, they tend to just give short answers with almost no comment or enthusiasm. They don't tend to want to sustain the activity.

Finally, two of the interesting, perhaps side, benefits of using the Socratic method are that it gives the students a chance to experience the attendant joy and excitement of discovering (often complex) ideas on their own. And it gives teachers a chance to learn how much more inventive and bright a great many more students are than usually appear to be when they are primarily passive.

[Some additional comments about the Socratic method of teaching are in a letter, "Using the Socratic Method".]

[For a more general approach to teaching, of which the Socratic Method is just one specific form, see "Teaching Effectively: Helping Students Absorb and Assimilate Material"]