S4S International

The One Skill That Matters

Teaching Entrepreneurs How to Think

The Theory and Practice of the 10 Questions Methodology and
The Use of the Socratic Method in its Delivery

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THE THEORY AND PRACTICE OF THE 10 QUESTIONS METHODOLOGY AND THE USE OF THE SOCRATIC METHOD IN ITS DELIVERY

MYTHS.

When stories are told about successful entrepreneurs two underlying lessons inevitably emerge: that they went out into the world to prove their belief and that they persevered in the face of, and ultimately overcame, near unanimous opposition. Unfortunately, the value of those two lessons, like many great myths, is undermined by survivor bias. There are many more untold stories of entrepreneurs who sallied forth to prove their theory and conquer the opposition whose businesses failed in silence. Even worse, these lessons do not merely not contribute to success, they can be significant contributors to failure.

MODELS.

When an entrepreneur starts a business, they have a theory of how that business will operate. They have devised a business model that, they think, answers a series of key questions: Who is the customer, what is their problem or desire, how will they solve the problem, why will it be profitable, and more. Yet, like all theories, it rests on a set of implicit and explicit assumptions that the entrepreneur necessarily made in order to imagine the model.

In truth, startups are not businesses. They are temporary organizations in search of a business model[1]. Business models describe how a business creates, delivers and captures value.[2] They are, at heart, stories — stories that explain how businesses work.[3][4]

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[1] Steve Blank

[2] Harvard Business Review definition

[3] "Telling a Good Story. The word "model" conjures up images of white boards covered with arcane mathematical formulas. Business models, though, are anything but arcane. They are, at heart, stories—stories that explain how enterprises work."
Why Business Models Matter. (2002). *Harvard Business Review*. Retrieved 29 July 2018, from https://hbr.org/2002/05/why-business-models-matter

[4] Consider the story behind one of the most successful business models of all time: that of the traveler's check. During a European vacation in 1892, J.C. Fargo, the president of American Express, had a hard time translating his letters of credit into cash. "The moment I got off the beaten path," he said on his return, "they were no more use than so much wet wrapping paper. If the president of American Express has that sort of trouble, just think what ordinary travelers face. Something has got to be done about it."1 What American Express did was to create the traveler's check—and from that innovation evolved a robust

It is only in hindsight, when we recount the story, that business models seem to have evolved smoothly out of the organization's early days. The reality is that the search for a business model, or evidence to support a new business model, comes in fits and starts, confounded by blind alleys and rabbit holes, into which they wander or fall. In fact, the best state of mind for an entrepreneur is the antithesis of blind faith; it is the critical self-awareness of the temporary state they are in and the continual probing of the model and the assumptions on which it rests.

The ability to be dis-passionate about the model and to have the interrogatory tools necessary to question the model is the hallmark of a great entrepreneur. It follows, then, that teaching new entrepreneurs how to systematically question a potential business model and to instill in them the self-confidence to realize that models can come and go, is the best preparation they can have.

METHODS AND METHODS.

There are many strongly held views on the methods by which one should approach the investigation; most of which hold an inherent positive bias for technology-centric startups embedded in mature ecosystems, like the Valley. By way of example, the notion of an MVP, a minimum viable product, is a popular trope in these methods. An MVP is completely appropriate for an app or a web service, where the features and functions can be treated in isolation.

But outside of technology, where for example, one is starting a chocolatier in a rural area of cocoa production or a music label in the urban heart of a developing country; such concepts do not neatly fit. *"The problem with simple*

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business model with all the elements of a good story: precisely delineated characters, plausible motivations, and a plot that turns on an insight about value.

The story was straightforward for customers. In exchange for a small fee, travelers could buy both peace of mind (the checks were insured against loss and theft) and convenience (they were very widely accepted). Merchants also played a key role in the tale. They accepted the checks because they trusted the American Express name, which was like a universal letter of credit, and because, by accepting them, they attracted more customers. The more other merchants accepted the checks, the stronger any individual merchant's motivation became not to be left out.

As for American Express, it had discovered a riskless business, because customers always paid cash for the checks. Therein lies the twist to the plot, the underlying economic logic that turned what would have been an unremarkable operation into a money machine. The twist was float. In most businesses, costs precede revenues: Before anyone can buy your product, you've got to build it and pay for it. The traveler's check turned the cycle of debt and risk on its head. Because people paid for the checks before (often long before) they used them, American Express was getting something banks had long enjoyed—the equivalent of an interest-free loan from its customers. Moreover, some of the checks were never cashed, giving the company an extra windfall.

replication, however, is that emerging market entrepreneurs, ventures, and ecosystems can be quite different. Therefore, the same kind of program run in two different contexts might produce very different results."[5]

Further to the point, the key to learning is less about what to teach and more about how to teach. Most of the popular tools and techniques flowing from the Valley focus on teaching students what they need to know and what they need to do; when the actual challenge is arming them with critical thinking skills and empowering them with the resilience to endure the journey.

The second concern, teaching resilience and instilling self-confidence, is almost irrelevant in the heart of a vibrant ecosystem where examples of success abound, and events to support and encourage young entrepreneurs are scheduled on top of each other every night of the week. But ecosystems, outside of a few exemplary clusters in the US and Europe, are almost uniformly incomplete, thus it falls on whoever offers teaching and support to offer it holistically. Though it is beyond the scope of this paper, teaching the soft skills and filling in the gaps in ecosystems is covered in other S4S materials.[6]

CRITICAL THINKING

Teaching critical thinking is not easy. As Daniel Willingham put it, in his seminal essay on the subject;

> *"Virtually everyone would agree that a primary, yet insufficiently met, goal of schooling is to enable students to think critically. In layperson's terms, critical thinking consists of seeing both sides of an issue, being open to new evidence that disconfirms your ideas, reasoning dispassionately, demanding that claims be backed by evidence, deducing and inferring conclusions from the available facts, solving problems, and so forth."*[7]

He observed that, *"critical thinking is not a set of skills that can be deployed at any time, in any context. It is a type of thought that even 3-year-olds can engage in—and even trained scientists can fail in. And* ***it is very much dependent on domain knowledge and practice****."*[8] *(Ed. Highlight).* In the context of critical thinking or problem solving, domain knowledge is described as the "surface structure" of the problem, while the tools to solve the problem are the "deep

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[5] Roberts, P. and Eden, G. (2018). *Accelerating Startups in Emerging Markets: Insights from 43 Programs*. [online] Galidata.org. Available at: https://www.galidata.org/assets/report/pdf/Accelerating Startups in Emerging Markets.pdf [Accessed 3 Jul. 2018].

[6] See The S4S Approach to Measuring Incubators and Accelerators and S4S Overview 2019

[7] Critical Thinking Why Is It So Hard to Teach? Daniel T. Willingham. American Federation of Teachers. 2007

[8] Critical Thinking Why Is It So Hard to Teach? Daniel T. Willingham. American Federation of Teachers. 2007

structure." In our context, knowing what elements make up a business (clients, markets, pricing etc.) and how they relate in a business model are the surface structure while the method to analyze a given business is the deep structure.

This is important because almost unilaterally entrepreneurs are taught the surface structures; how a business model works, what the included elements mean, etc. At the same time, they are exhorted to test their assumptions, and be "scientific". Willingham notes though that, "*Just as it makes no sense to try to teach factual content without giving students opportunities to practice using it, it also makes no sense to try to teach critical thinking devoid of factual content*"[9]

It is not enough to teach what business models are, how they work or even each of the elements in detail. There is a collateral requirement to teach how to analyze that content. Willingham identifies two factors that determine whether critical thinking skills will be learned: *"familiarity with a problem's deep structure and the knowledge that one should look for a deep structure."*[10] Familiarity he concludes come from repeated experience with the deep structure across a range of surface structures. In simple terms, teaching entrepreneurs to successfully analyze their businesses requires that they learn:

1. An analytic tool to interrogate their models (the deep structure),
2. The domain knowledge about how a business works and what each of the key factors in a business are (the surface structure) and
3. And repeated experiences applying that across a variety of different fact sets.

Or as Whitmore put it, "***Practice, Practice, Practice:*** *It requires practice to master, and it works best when introduced in a variety of settings so that students can learn how to transfer the skill to novel situations*"[11]. Which neatly leads us to our initial point that the emphasis should be less on what to teach and more on how to teach.

SOCRATIC METHOD

> *"Socratic questioning is disciplined questioning that can be used to pursue thought in many directions and for many purposes, including: to explore complex ideas, to get to the truth of things, to open up issues and problems, to uncover assumptions, to analyze concepts, to distinguish what we know from what we don't know, and to follow out logical implications of thought. The key to distinguishing Socratic questioning from questioning per se is that Socratic questioning is systematic, disciplined, and deep, and usually*

[9] Ibid.
[10] Ibid.
[11] Why Is Critical Thinking Difficult to Teach? – Credo Education
Why Is Critical Thinking Difficult to Teach? – Credo Education. (2017). Credoeducation.com. Retrieved 29 July 2018, from http://www.credoeducation.com/why-is-critical-thinking-difficult-to-teach/

> *focuses on foundational concepts, principles, theories, issues, or problems."*[12]

Socratic method is an approach to teaching where the teacher guides the students by asking questions and in so doing, engages the student in applying the deep structures, thus acquiring the skill to do so on their own. This is the key transferable skill they carry with them as they endeavor to develop a sustainable business model. In fact, it is a capacity that they take with them long beyond their first business; it gives them insight into their own businesses, but also in businesses all around them; once learned they see business through a new lens and with a deeper understanding.

Socratic Method exists in the modern world. It can be found in its purest form in American law schools, where it is used to teach aspiring lawyers how to look at a case from all sides and to untangle the deep structures, the law, from the surface structures, the facts. It can be found, somewhat diluted, in the Harvard case study approach, where each case study presents a new surface structure, but the analysis of which, when applied, reveals the analytic model beneath.

Perhaps the most telling example of the power of teaching Socratically was an experiment performed by a researcher, Rick Garlickov, where he tried to teach binary arithmetic to twenty-two 9-year old's on a Friday afternoon two weeks before the school year ended. Two independent teachers who observed predicted that only two of the twenty-two children would be able to understand what Rick was attempting to teach. At the end of the class some 40 minutes later, 19 of the twenty-two students could count in base 2. (*The entire transcript is attached for fascinating reading in Appendix B.)*

THE 10Qs™

Socratic Method also forms the basis of the S4S approach to teaching entrepreneurs. It is so embedded in our practice that our analytic method, the 10 Question Methodology (the 10Q Method), is itself organized as a series of questions. By presenting the analytic model as questions there is no friction between the teaching method and the analytic model. *(A list of the 10 questions and 100 representative sub-questions can be found in Appendix A.)*

The Willingham insights also permeates our program structures.

A. When large audiences of entrepreneurs are taught together, the Socratic conversation between the teacher and the entrepreneur, permits them to

[12] The Art of Socratic Questioning | Critical Thinking. (2018). Criticalthinking.org. Retrieved 29 July 2018, from https://www.criticalthinking.org/store/products/the-art-of-socratic-questioning/231

follow along testing their own skills against the teacher, and driving the repetition that is key to mastery,

B. Each entrepreneur brings their own business to the classroom. The classes work around real businesses or real ideas. The entrepreneur brings their domain knowledge and surface structure with them; and leave with an analysis underway and deep structure competency to take it forward,
C. The entrepreneurs are regularly grouped into small groups where they critique each other's business models, learning how to be the Socratic questioner as well as the student in the dialectic once again forcing them to engage the critical skill on a new set of facts, and
D. New teachers act as facilitators for current teachers to help transfer the Socratic skills as part of our core mission to develop local capacity wherever we teach.

S4S has used Socratic Method and the 10Q Method with entrepreneurs from every culture and every walk of life. Tens of thousands of students have learned how to become inquisitors of business and their models. They have regularly given us the feedback that it changed how they grew their business, how they understood how business worked, and to a degree how they understood the world around them.

Equally importantly, their mastery at this form of critical thinking gave them confidence. It assured them that they had the skills within themselves to be confident about their judgements and it gave them the resilience to bounce back again and again as they rode their startups to success.

Appendix A

The 10QTM method was designed as an analytic method that complemented the Socratic approach to teaching business model analysis. The Questions listed below are representative of the type of guided questioning that is involved in a Socratic dialogue. This is not an exhaustive list.

Question 1: What do you do that people need or want?

1. Why do you say that?
2. What is your promise?
3. What is your story?
4. What evidence do you have of need or want?
5. How do you know that your product is answering a need or fulfilling a desire?
6. How can you verify or disprove your assumptions?
7. What could we assume instead from that evidence?
8. How do you create value for your customers?
9. What 'jobs' are your customers seeking to address (functional / emotional / social / intellectual etc.)
10. What problem can you solve better than the competition?
11. How do you know this?
12. What could a minimal viable product look like?
13. What would be an example?
14. How does this apply to the rest of your business model?

Question 2: Who are your customers?

1. What is your total available market? And your total accessible market?
2. How many different customer groups are you intending to sell to?
3. Are they equally easy to reach?
4. Have you determined the size of each segment?
5. How can you verify or disprove that assumption?
6. Can you list your customer attributes?
7. How would you describe your target customer segments?
8. What would be an example?
9. What B2C and B2B segments are you targeting?
10. Are you operating a single or multi sided model?
11. What would be an alternative?
12. What generalizations can you make?
13. How would you prioritise market segments (value / ease of reach / fastest growing / easiest to test)
14. How are you creating value profitably?
15. How does this apply to the rest of your business model?

Question 3: Who are you up against?

1. Why do you say that?

2. How do you define the competition?
3. Who else is solving the problem that you are?
4. What can you learn from your competitors?
5. What advantages does your product or service have?
6. What advantages are you building into your business model, not your product or service, to increase your competitiveness?
7. How do you anticipate your competitors will respond?
8. How can you sustain your advantage after your competitors have responded>
9. How else can you compete?
10. How can you verify or disprove that assumption?
11. How might you collaborate or co-create with competitors?
12. How does your model protect you from the competition?

Question 4: What do we have in common?

1. What trends are impacting your industry?
2. Is there potential legislation that may affect your business?
3. How are social mores changing that may impact your business?
4. What impact could future technology have on your product or service or the way you do business?
5. How can you predict future trends?
6. Which trends could make or break your business in the future?

Question 5: How will you reach your customers?

1. How will you acquire new customers?
2. How will you retain them?
3. How will you grow them?
4. What are the different routes to finding customers?
5. What are the different ways for you to connect your company to your customers?
6. Which channels will you use (awareness / distribution / sales / evaluation / after sales)?
7. How much does your business model get customers or third parties to create value for you?
8. Who currently reaches your customers that you would like to have help from?
9. What could you do for them in return?
10. Are there people or organisations that are influencers (reviewers or organisations that rate quality?
11. Have you created a pricing structure that lets third parties make money if they sell the product for you?
12. Who would you approach to sell your product for you in other countries?
13. Whose endorsement would change the perception of your product the most?
14. How would you reach them?

15. Has your pricing strategy included not competing against your own distributors or retailers?

Question 6: What relationship will you have with them?

1. What financial relationship do you want to have with your customers?
2. What level of customer intimacy will you have?
3. How will you decide between a direct and indirect relationship?
4. How might your acquisition and retention strategies vary for low and high value customers?
5. How can you lock customers in to your business through the nature of the relationship you have with them?
6. How easy or difficult is it for your customers to switch to another company?

Question 7: What is it worth to them?

1. How much should you charge for your product or service?
2. What are your customers willing to pay?
3. What are the business costs that you need to factor into your pricing model?
4. What will you charge your customers?
5. What evidence will you use to make these decisions?
6. What assumptions are you making about how your customers perceive value?
7. How can you prove or disprove these?
8. What are the ways that you can increase the value of your product or service without adding to costs?
9. How will make decisions about the best pricing mechanism to adopt?
10. What are the pros and cons of adopting a low costs vs value vs premium model?
11. Are you going to follow a cost driven or value driven model?
12. How scalable is your business model?
13. How is this best achieved — economies of scope or scale?

Question 8: Who is the key partner?

1. Who is also trying to target the same market as you?
2. How does this link back to other aspects of your business model e.g. competition?
3. How can suppliers, distributors and marketing companies become key partners?
4. Who can you bring on board to help you deliver your value proposition?
5. How can you develop partnerships that will help leverage from your business model and provide a win win?

Question 9: What is the key asset?

1. What do you have to your advantage, to help you win customers?
2. Is it physical, intellectual, human or financial?
3. How can you best protect and exploit these assets?
4. What assets can you acquire that will reduce your costs or increase your sales so your profit rates go up?

Question 10: What is the key competency?

1. What do you need to be good at to deliver your business model?
2. Are there any activities that you could outsource to improve your business model?
3. Which competencies must you retain in house to deliver your value proposition most profitably?
4. What are you personally good at?
5. What are you weakest at?
6. Is there anyone on your team who is good at what you are not?
7. What role do they play or influence do they have over you?

APPENDIX B

The Socratic Method: Teaching by Asking Instead of Telling
By Rick Garlickov

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.]

What follows is a somewhat summarized transcript of the discussion. 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 write 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 zeros and ones back into numbers or letters, so we humans, who can't read long strings of zeros and ones very well can know what the answers are.

[at this point one of the kids 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.