



## Socrates, How Is Engineering Knowledge Attained?

By Erik Anders Nelson, P.E., S.E.

Could Socrates help us understand how structural engineering knowledge is attained? We know from his actions, and through Plato's writings, that he is clearly able to help us understand the importance of a liberal education. How does this translate to engineering education? For Socrates, education within any classroom needs to foster freedom and inquiry. He is someone who literally lost his life in defense of the spirit of inquiry (read the *Apology* or *Crito*). The most telling dialog of Socrates on the importance of inquiry is Plato's *Meno*. It is where we find Socrates asking fundamental questions about learning itself and the method of attaining knowledge. The following text was written by Plato in 380 B.C.E. and translated by Benjamin Jowett. I am going to borrow and edit heavily the entire dialog (even replace words) because I think this is exactly the type of conversation that should take place in all of our classrooms. Not only does it teach us the importance of the Socratic method of inquiry, it also can also help us as educators.

*Meno.* Can you tell me, Socrates, whether structural engineering is acquired by theory or by practice; or if neither, then whether it comes to man through testing nature, or in what other way?

*Socrates.* Oh Meno, you have far too good an opinion of me, if you think that I can answer your question. For I literally do not know what structural engineering is, and much less how it is acquired. I confess with shame that I know literally nothing about engineering.

*Meno.* And how will you enquire, Socrates, into that which you do not know? How do we learn something of which we have no knowledge?

*Soc.* I will tell you how: All enquiry and all learning is but recollection. We do not learn, we recollect.

*Meno.* What do you mean by saying that we do not learn, and that what we call learning is only a process of recollection? Can you teach me how this is?

*Soc.* I told you, Meno, and now you ask whether I can teach you, when I am saying that there is no teaching, but only recollection; and thus you imagine that you will involve me in a contradiction!

*Meno.* Indeed, Socrates, I protest that I had no such intention. I only asked the question from habit; but if you can prove to me that what you say is true, I wish that you would.

*Soc.* It will be no easy matter, but I will try to please you to the utmost of my power. Suppose that you call one of your numerous uneducated slaves, that I may demonstrate on him that the question of learning is recollection. We will have to get to what structural engineering is another day – and concentrate on how one knows things. I will, however, use the area of a column as an example – something I am sure is used by the structural engineer.

*Meno.* Certainly. Come hither, boy.

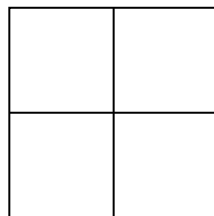
*Soc.* Tell me, boy, do you know a figure like this section of a column? Is it not a square?

*Boy.* Yes, I do. It is a square.

*Soc.* And you know that a square figure has these four lines equal?

*Boy.* Certainly.

*Soc.* And these lines which I have drawn through the middle of the square are also equal?



*Boy.* Yes.

*Soc.* A square may be of any size? So a column may be of any size?

*Boy.* Certainly.

*Soc.* And if one side of the column be of two feet, and the other side be of two feet, how much area will the whole column be? Let me explain: if in one direction the column was of two feet, and in other direction of one foot, the whole would be of two feet taken once?

*Boy.* Yes. So two by two would be four square feet.

*Soc.* Good. And might there not be another square column with an area twice as large as this? And what is the area of that doubled column?

*Boy.* Eight square feet of course.

*Soc.* Correct. And now try and tell me what is the length each side if the area of the square column is eight?

*Boy.* Clearly, Socrates, it will be double the length of the side, so each side will be four.

*Soc.* Do you observe, Meno, that I am not teaching the boy anything, but only asking him questions; and now he fancies that he knows how long the side of the column is necessary in order to produce a column of eight square feet; does he not? And does he really know?

*Meno.* Certainly not.

*Soc.* Observe him while he recalls the steps in regular order. (To the Boy.) Tell me, boy, do you assert that double the area comes from doubling the side?

*Boy.* Yes

*Soc.* But does not this line become doubled if we add another such line here?

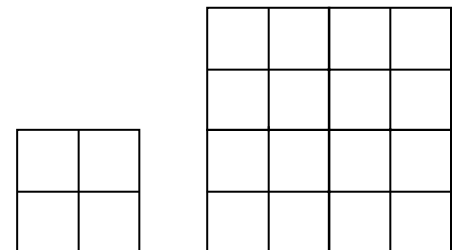
*Boy.* Certainly.

*Soc.* And are there not these four divisions in the figure, each of which is equal to the figure of four feet?

*Boy.* True.

*Soc.* And four times is not double is it?

*Boy.* No, indeed. It is four times as much.



Sixteen! Oh no – that column is huge!

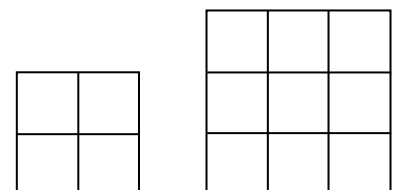
*Soc.* So, what side length would give you a space of eight square feet? Is not a space of eight, half the size of sixteen?

*Boy.* Certainly.

*Soc.* Then the line which forms the side of eight square feet ought to be more than this line of two feet, and less than the other of four feet?

*Boy.* It ought.

*Soc.* Try and see if you can tell me how much it will be.



Boy. Three feet.

Soc. And how much are three times three feet?

Boy. I am counting and I am close but nine is not eight. So I was wrong again!

Soc. But from what length of line would give you eight square feet? Tell me exactly; and if you would rather not reckon, try and show me the line.

Boy. Indeed, Socrates, I do not know.

Soc. Do you see, Meno, what advances he has made in his power of recollection? He did not know at first, and he does not know now, what is the side of a column of eight square feet: but then he thought that he knew, and answered confidently as if he knew, and had no difficulty; now he has a difficulty, and neither knows nor fancies that he knows.

Meno. True.

Soc. Is he not better off in knowing his ignorance? If we have made him doubt, and given him the “torpedo’s shock,” have we done him any harm? We have certainly, as would seem, assisted him in some degree to the discovery of the truth; and now he will wish to remedy his ignorance, but then he would have been ready to tell all the world again and again that double the area should have a double side. He would have lived his entire life with false knowledge – and this is just area stuff, I have not even discussed column buckling!

Meno. True.

Soc. But do you suppose that he would ever have enquired into or learned what he fancied that he knew, though he was really ignorant of it, until he had fallen into perplexity under the idea that he did not know, and had desired to know?

Meno. I think not, Socrates.

Soc. Mark now the farther development. I shall only ask him, and not teach him, and he shall share the enquiry with me: and do you watch and see if you find me telling or explaining anything to him, instead of eliciting his opinion. Tell me, boy, is not this a square of four feet which I have drawn?

Boy. Yes.

Soc. And how many times larger is this space than this other?

Boy. Four times.

Soc. But it ought to have been twice only, as you will remember. And does not this line, reaching from corner to corner, bisect each of these spaces?

Boy. Yes.

Soc. And how many spaces are there in each section?



Boy. Two, since there are two triangles and one square.

Soc. And four is how many times two?

Boy. Twice, two times two is four.

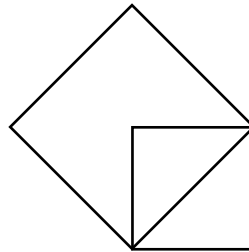
Soc. And from what line do you get this figure?

Boy. From this.

Soc. That is, from the line which extends from corner to corner of the figure of four square feet?

Boy. Yes.

Soc. And that is the line which the learned call the diagonal. And if this is the proper name, then you, boy, are prepared to affirm that in order to double the area of the column, you would square the diagonal?



Boy. Certainly, Socrates.

Soc. What do you say of him, Meno? Were not all these answers given out of his own head?

Meno. Yes, they were all his own.

Soc. And yet, as we were just now saying, he did not know?

Meno. True.

Soc. But still he had in him those notions of his – had he not?

Meno. Yes.

Soc. Then he who does not know may still have true notions of that which he does not know? Without any one teaching him, he will recover his knowledge for himself, if he is only asked questions? And this spontaneous recovery of knowledge in him is recollection?

Meno. True.

Soc. And this knowledge which he now has must he not either have acquired or always possessed?

Meno. Yes.

Soc. And if there have been always true thoughts in him, both at the time when he was and was not a man, which only need to be awakened into knowledge by putting questions to him, his soul must have always possessed this knowledge, for he always either was or was not a man?

Meno. I feel, somehow, that I like what you are saying.

Soc. And, Meno, I like what I am saying. Then, as we are agreed that a man should enquire about that which he does not know; that is a theme upon which I am ready to fight, in word and deed, to the utmost of my power.

In other words, we should want our students to acquire the freedom that allows them to acknowledge the one certainty in life: “Indeed, Socrates, I do not know.” Recognition of that certainty – we are all ignorant – is the pathway to learning. Then learning things will belong to them, instead of just repeating things that belong to others (memorization of facts, test-taking, etc). Future engineers need to process the tools resulting from a liberal education to help us listen and read attentively and deeply, to express ourselves intelligibly and precisely, to measure and question the world, and to seek truth. This will help us become life-long learners. Another useful result is that it will make us better at understanding the highly technical and theoretical aspects of engineering, too.

This may also assist us in deciding difficult questions, such as: Is it a good idea to teach a class that is new, like “Sustainability in Civil Structures” or the highly technical “Advanced Matrix Analysis,” and replace classes that reinforce the basics? There are only so many hours in the current curriculum, so this is important. However, we know that regardless of which class we may add – and consequently which class we remove – every class needs to foster enquiry. We need to resist cramming students’ heads with more and more knowledge (so-called), whether it is more mathematics, new theory based on a particular research agenda, or trends in the marketplace. This may numb the minds of our future engineers. Teaching should be about assisting the student in discovery – i.e., a liberal education – not supplying information or listing the latest facts.

We do not want engineers who merely regurgitate what they have been taught and what they have memorized. We want them to struggle, and to engage the world and people in meaningful ways. We want engineers with a spirit of inquiry and love of learning that will last a lifetime. So even if we add courses that submit to trends in the marketplace or wrongly decide that our students need more mathematics, we had better make sure that Socrates joins every class. ■

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