

The measurand may not necessarily be the “quantity subject to measurement”, but it is always the “quantity intended to be measured”

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Published online: 8 November 2007
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The perception of the concept ‘measurand’ should be unambiguously clear in the mind of the analyst or scientist who measures before a measurement is even started, lest (s)he does not know very well what (s)he is measuring. Doubt after the measurement about what the measurand actually was and for what the measurement result is intended, can cost time and energy, spent for nothing. That there are very different perceptions of the concept ‘measurand’, can be observed in the following story related by Sir Ernest Rutherford, President of the Royal Academy, and recipient of the Nobel Prize in Physics:

Some time ago I received a call from a colleague. He was about to give a student a zero for his answer to a physics question, while the student claimed a perfect score. The instructor and the student agreed to an impartial arbiter, and I was selected. I read the examination question: “Show how it is possible to determine the height of a tall building with the aid of a barometer”. The student had answered: “Take the barometer to the top of the building, attach a long rope to it, lower it into the street, and bring it up, measuring the length of the rope. The length of the rope is the height of the building”.

The student really had a strong case for full credit since he had really answered the question completely and correctly! On the other hand, if full credit were given, it could well contribute to a high grade in his physics course and certify competence in physics, but the answer did not confirm this. I suggested that the student have another try. I gave the student 6 min to answer the question with the warning that the answer should show some knowledge of

physics. At the end of five minutes, he had not written anything. I asked if he wished to give up, but he said he had many answers to this problem; he was just thinking of the best one. I excused myself for interrupting him and asked him to please go on. In the next minute, he dashed off his answer which read: “Take the barometer to the top of the building and lean over the edge of the roof. Drop the barometer, timing its fall with a stopwatch. Then, using the formula $x = 1/2 gt^2$, calculate the height of the building”. At this point I asked my colleague if he would give up. He conceded and gave the student almost full credit.

While leaving my colleague’s office, I recalled that the student had said that he had other answers to the problem, so I asked him what they were. “Well”, said the student, “there are many ways of getting the height of a tall building with the aid of a barometer. For example, you could take the barometer out on a sunny day and measure the height of the barometer, the length of its shadow, and the length of the shadow of the building and by use of a simple proportion, determine the height of the building”.

“Fine”, I said, “and others?” “Yes”, said the student, “there is a very basic measurement method you will like. In this method, you take the barometer and begin to walk up the stairs. As you climb the stairs, you mark off the length of the barometer along the wall. You then count the number of marks, and this will give you the height of the building in barometer units”.

“A very direct method”. “Of course. If you want a more sophisticated method, you can tie the barometer to the end of a string, swing it as a pendulum, and determine the value of g at the street level and at the top of the building. From the difference between the two values of g , the height of the building, in principle, can be calculated”.

“On this same track, you could take the barometer to the top of the building, attach a long rope to it, lower it to just

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above the street, and swing it as a pendulum. You could then calculate the height of the building by the period of the precession”.

“Finally”, he concluded, “there are many other ways of solving the problem”.

“Probably the best”, he said, “is to take the barometer to the basement and knock on the superintendent’s door. When the superintendent answers, you speak to him as follows: Mr Superintendent, here is a fine barometer. If you tell me the height of the building, I will give you this barometer”.

At this point, I asked the student if he really did not know the conventional answer to the question. He admitted that he did, but said that he was fed up with high school and college instructors trying to teach him how to think.

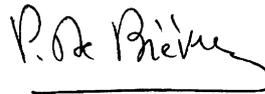
The name of the student was Niels Bohr.

The student first perceived the concept ‘measurand’ as a length and measured it as the “quantity subject to measurement”, i.e., the length of a rope. Then the student perceived the ‘measurand’ as the “quantity intended to be measured” (the height of the tower), but used a stopwatch and made some calculation to convert time into length.

In both cases he ended up with a measurement result which was related to what was to be measured (the ‘measurand’).

This story is a rather interesting illustration of the perception of the concept ‘measurand’, in this case the height of the building. One perception is that the ‘measurand’ is the “quantity subject to measurement” (the length of the rope, or the length of the shadow), as defined in the International Vocabulary of Basic and General Terms in Metrology, 1993. The other perception is that the ‘measurand’ is the “quantity intended to be measured”, as defined in the International Vocabulary of Metrology, Basic and General Concepts and Associated Terms, 2007.

It is important to have clear and unambiguous definitions of concepts and associated terms when describing a measurement.



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P.S. This story came to me through Philip Taylor (IRMM) from Jean-Charles Abbé, Directeur de Recherches at the University of Nantes (France).