



# OPINION

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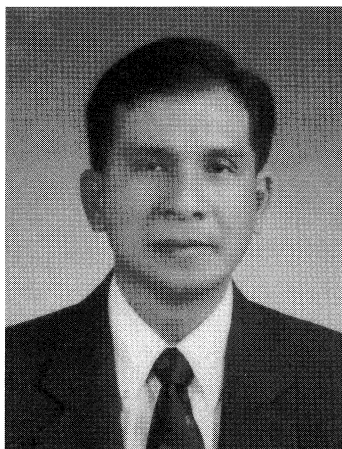
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## The Scientific Process: Should We Go Back to Basics?

Kate Grudpan

The “scientific process” has been realized for a long time for its usefulness. Generally, the process consists of: (1) to set objectives, (2) to state hypotheses, (3) to design and do experiments, and (4) to analyze results. Currently, in Thailand, the scientific process is introduced at high school level (or about grade 10–12). The students in such a class usually study in such a way as to remember items about the scientific process rather than to understand its real meaning. This happens with other subjects too. It might even be thought that the scientific process is only applicable to the (natural) sciences. In fact, the scientific process can be applied to every subject including marketing, business, law, etc.

In teaching natural science, especially laboratory exercises at the various levels in Thai educational institutions (both primary and high schools and universities), emphasis is usually placed on content at the expense of other equally important learning processes. Consequently, younger generations have not been properly trained to think for themselves and to develop their own individual skills in



problem solving. Their abilities are becoming similar to a computer, only being able to function if a work program has been set for them.

Let us take a simple example. In chemistry, a given volume of liquid may be measured out and added using a cylinder or a pipet. A student may know well enough what a cylinder is, similarly a pipet. But, after a period of time after they have

finished a laboratory course, the student may choose to use a cylinder instead of a pipet to take a sample for titration for the determination of its accurate concentration, or to use a graduated pipet for adding an indicator. Neither would be correct. It shows that the students did not really understand enough in concept in order to know how to choose which tool/item to use for a particular purpose.

In another example, a student might choose to use a glass for drinking water to perform the titration in, reasoning that it was appropriate for a situation (perhaps a school in a remote area) where there was not enough budget to purchase a beaker. Interestingly, such an excellent idea as this would be discouraged

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by many persons who would consider that using a drinking water glass would give unacceptable results. On the contrary, it would be perfectly acceptable.

The appreciation of experimental error is another case in point. In a demonstration, 50 ml 0.1 M HCl was mixed with 50 ml 0.1 M NaOH. The teacher and students would expect a pH value of the resulting solution to be 7 but, after measuring with a pH-meter, it was found not to be 7. Most of the students would suspect that the reason for this was that the pH meter was not good enough. Not many would think of other possibilities such as: were the HCl and/or NaOH solutions exact in their concentrations and/or volumes (e.g., 0.0981 M HCl and 0.1199 M NaOH; 51 ml HCl and 49 ml NaOH ... etc). Class discussion on the various sources of error in an experiment should be encouraged.

Significant figures are another important issue. Even public reports are often unaware of this. For example, in a weather report, we may be told that the highest temperature was 32.42 °C while the lowest temperature was 28.19 °C. Similarly, the results of a poll may claim that, from 528 samples taken, 70.13 % agreed with a proposed idea; 13.22 % disagreed; while 16.65% being neutral. Do the figures in the decimal places have any real meaning? This lack of appreciation of significant figures may even be found in a Master's or in a Ph.D. thesis.

These examples serve to remind us of how basic knowledge should be treated. Proper training in basic knowledge combined with a logical way of thinking and planning develops a conceptual mind. This is the way towards achieving genuine education advancement.