The Principles of Four Basic Steps of Scientific Stage : Problem, Hypothesis, Trial, Report

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The Principles of Four Basic Steps of Scientific Stage : Problem, Hypothesis, Trial, Report

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Abstract

Aim: to revisited four basic steps of scientific stage which consist of Problem, Hypothesis, Trial and Report.

Discussion: Scientific stage is a series consists of four consecutive steps which provide scientific explanation or even answer to research question based on observation, experiment, and comparison. It can be a positive or negative explanations rely upon a certain approach, called the scientific method, for their justification. This explanation or answer, in the context of the most basic human virtue, is to make the life of its perpetrators and also other people better.

Conclusion: Scientific stage conducted through four consecutive basic and simple steps is at the heart of evidence based activity conducted by scholars and scientist.

Keywords: Scientist, Scholar, research, observation, experiment, comparison

Introduction

Per definition, problem is a matter or situation considered as unacceptable or unwanted or detrimental and needing to be dealt with and overcome using problem solving activity [1]. It is a clear gap between what is expected and what actually exists [2]. Every life has certain problems correlated with it and by successfully uncovering meaning or explanation or even answer to that problem will help people to be able to sustain the effort needed to overcome the particular problems [3].

The scientific approach can be used to solve routine or non-routine everyday problems and practice make it perfect [4]. Science actually is more of a continuous progress of studies rather than just a body of knowledge [5]. In a routine daily lives, sudden and irrational reaction conducted as rapid response in order to jump to quick solutions whenever faced with problems, In fact, sometimes it actually makes the problem worse. But following the four steps of the scientific process can help to slow down, reduce tension and discover more intelligent solutions.

Problem solving actually included in the scope of science [6]; its awesome power and its essence make science different from the non-scientific approach in the context of process and of course result [7]. By knowing and understanding what science is, somebody can used it to solve the problem. It is a method that generally consists of observing [8], hypothesizing based on the problem solving [9], and testing through experiments or trials[10]. This method is what all the

sciences have in common. The aim of this short review is to revisited four basic steps of scientific stage which consist of Problem, Hypothesis, Trial and Report.

The scientific approach to problem solving

The scientific approach to problem solving is a systematic and objective mechanism of (1) explaining a condition, (2) answering questions, and even can be directed to (3) finding a solution [11]. Scientific approach of solving problem must be consistent in the result's reproducibility and replicability [12]. The application of non-scientific option that might be requires during problem-solving activity conducted without applying any scientific principles. Non-scholars individuals do not have the capability for predicting the exact outcomes of the issue they are solving. They usually prefer methods such as intuition and traditional knowledge to solve problems, methods which cannot be accounted for. A non-scholar individual may utilize logic to bypass a problem but it may be insubstanstial because it all hinges on the individual's view of their life based on their previous encounter with the almost similar situation or problem. If the individual has never had any prior experience at all then his instincts to solve the almost similar problem will become very dull.

Scientifically, stages in solving problems are rigid, and involves: (1) Problem: defining a problem as lucid as possible, (2) Hypothesis: generating a hypothesis to be answer, (3) Trial: determining the necessary data required to solve the problem and (4) Report: all the data collected finally being used to test the hypothesis and made conclusion [13].

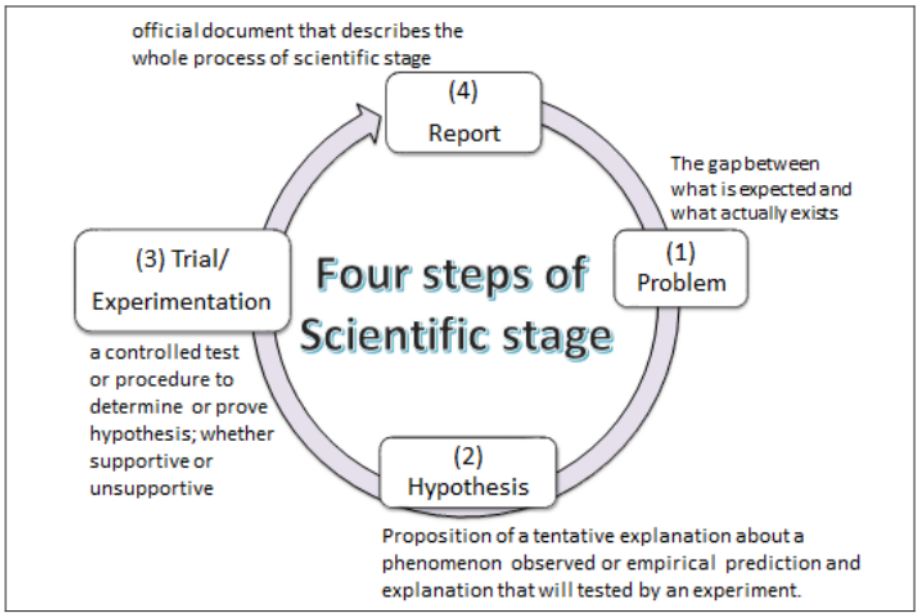

Fig. 1. The four steps of Scientific Stage [13, with modification]

Problem Identification

Research is frequently so-called as a problem-corrective action, and certainly as a consequence, elucidation of the problems and its alternative remedies are a requisite portion of the scientific approach applied to delineate research activity [1]. The scientific method can be described as a multistep and detailed process, in which finding the best question through problem identification and analysis is the first and most crucial step [14]. Data regarding the problem should be collected first, as comprehensive as possible, using a variety of methods [15]. One classic way every scholar all habituated to is the ideal 5 W and 1 T: who, what, where, when, how, and to what extent?

Fundamentally, the scientific method works best when you have a problem that can be measured or quantified in some way and the first step of problem identification is by "Question." It is better if question should be worded, indicating that the culprit really understands the essence of the problem so that it can be simply answered through experimentation. With the aid of high-throughput data generation, data mining, and advanced computational modeling, the size of the problem can provide enormous wealth of data and in combination with the power of machine learning, some scholars have even declared that notable interdependence within various datasets would make the whole pursuit for causation become obsolete [16].

Problem Identification consists of: (1) clearly identifying the root cause of a problem [17], this can be start as personal problem and then perhaps developed into (2) the much bigger problem or has impact on a wider group or population [18] and for such group usually called stakeholders; stakeholders are people or groups closely affected by or concerned with the problem and are always interested in policy/regulation solutions to overcome or solve the problem and last but not least (3) elaborating a detailed problem statement that embraces the whole problems, including any unnoticed underlying condition; all of these three become the principles of continuous quality improvement (QI) methods [19].

A scholar or a scientist need to make sure that he/she is identifying the true, underlying problem causing the issue—and eventhough this is not always obvious. Usually there are three ways to identify problems, namely by

1. talking/interviewing people who experiencing the problems which is the starting point of the targeted scientific stage. Identify the root cause of the problem by collecting information through interviewing or talking with stakeholders [20]. information from stakeholders can provide a scholar some insight into the problem and its causes. First hand information from trusted individuals or community leaders or any experts who experience problems directly is of course more convincing [2]; especially if the time of occurrence is not too long ago so that the risk of information bias can be minimized [22]; Problems are unique to their contexts, so in depth interview with several different stakeholders always recommended in order to attain the whole frame of the picture [23].
2. studying the literature [24]. By combining the identification existing initial problem and consider carefully all the data sources could help a scholar more clearly define the problem [25]. Start by doing an environmental scan [26], a literature study and review

[27], and if necessary, surveys in the community [28]; combining these three can help a scholar to better understand what is the contributing factors to the problem (underlying conditions) and identify possible solutions or at least getting the answer to the "question";

3. a combination of talking or interviewing with those who have experienced and then conducting literature studies to build better understanding regarding the problem [29]. This option perhaps be the most complex and most demanding, technically and financially, but the elaboration result is certainly framing the problem accurately and perhaps better than the first two mentioned.

The capability to describe an accurate, informative, concise, and attractive but still straight forward problem or research question is a valuable skill for scholars and writing a good statement regarding problem requires a considerable amount of time, effort, practice, mentoring, and [30] . Determining the problem at hand concisely so that it becomes a solid statement or perhaps in a straight to point question sentence to be answered, in my opinion, more towards the art of science than just pure science.

Hypothesis Formulation

Hypothesis is an idea that proposes a tentative explanation about a phenomenon or a narrow set of phenomena observed in the natural world or in other word, it is a prediction or explanation that is tested by an experiment [31]. Hypothesis alone is clearly empirical. Many definition express it as an "educated guess" based on antecedent expierence and knowledge; both in combination with observation [32]. Study question/hypothesis or objective is a clear statement of the core of the problem and hypothesis is actually tested using method which is suitable for it to gain answer for the question/problem [33].

Just Like problem framing, there are many tools and mechanisms available to assist someone in ideation, prototyping and creation for identifying a hypothesis. If the problem and hypotheses both combined, we can see that the next step of scientific stage, the "experimentatiton/trial" actually aimed to address the problem in the most effective way available [34]. If hypothesis proven after a while, it can become a fact.

The scientific method compulsory that a hypothesis must be winnow out or at least reshaped or adjusted if its divination are clearly and incessantly conflicting with the result of experimental tests [35]. Hypotheses are subject to researcher's bias and misinterpretation [36]. But with controlled close observation and suitable experimentation prevent the risk of bias/error to happen [37]. Rookie scholars occasionally make a few quotidian mistakes. The three most common basic error conducted is:

1. to mistakenly consider the hypothesis for an explanation of a phenomenon without performing experimental tests and following all the steps outlined above,
2. to ignore or rule out data that do not support the hypothesis,

3. the failure to identify widespread numerical or logical errors.

"Hypothesis" is a term often confused with "theory." A theory is the end result of a previously tested hypothesis, meaning a proved set of principles that explain observed phenomena. Thus, a hypothesis is sometimes called a "working hypothesis," to avoid this confusion. A working hypothesis needs to be proved or disproved by investigation. The entire approach employed to validate a hypothesis is more broadly called the "hypothetico-deductivism" method [38]. Not all hypotheses are proved by empirical testing, and most knowledge regarding the economy, humanitarian and ancient civilizations is solely relied on just observation and thoughts [39]. Furthermore, as the nature of human being, philosopher in the non-natural disciplines glimpse many erroneous conditions regarding the scientific method [40] because scientific approach only see partially and does not entirely reflect the chaotic environment that we live in—that is, the scientific method is rigid and constrained in its design and produces results that are isolated from real environments and that only address specific issues [16]. This is the main difference between the two science [41].

Trial or Experimentation

Trial and or experimentation or assesment in scientific methods is the third steps in scientific stage. A trial is a test of a hypothesis or a new procedure, usually in a limited context, such as a small group of subjects or a single test environment while an experiment is a procedure designed to determine whether observations of the actual world acknowledge with or deny the gleaned predictions in the hypothesis. If evidence from an experiment supports a hypothesis, that gives the hypothesis more credibility [42,43]. The purpose of a trial or experimentation or assesment is to gather evidence to support or refute the hypothesis and to determine the feasibility and effectiveness of a new procedure [42].

Experimentation or trial or assesment is obviously critical step in implementing the scientific method and can have a great effect on the results and conclusions a scholar extractss from an experiment. Careful thought and time should be devoted to experimental design and minimizing possible errors [34,36,37]. The experiment should be calculated and controlled closely so that every variable or factor that could interfere the outcome of the experiment be subservient of the researcher. Two types of variables are used to describe the conditions in an experiment: the independent and the dependent, or response, variable [37]. The independent variable is directly maintained or controlled by the researcher, sometime it called control variable, and is generally what one predicts will affect the dependent variable. The dependent, or response, variable thus depends on the value of the independent variable [45]. Experiments are generally designed so that one specific factor is manipulated in the experiment in order to illuminate cause and effect relationships.

Another important aspect in experimental design is the role of the control treatment, which constitutes a non-manipulated handling. The control treatment is kept in the same conditions as

the experimental treatment, but the experimental manipulation is not applied to the control [46]. The control maintain a commencement of "normal" conditions with which to compare the experimental treatments [46].

Experimentation or trial should also incorporate replication possibility of each treatment [12,37]. Repeatability of experimentation or trial steps and results is an important part of the scientific method that ensures the validity and accuracy of data gained through all the process[12]. It is quite hard to try to balance all aspects of an experiment so there is inherent variation in results that cannot be controlled for even under the most carefully designed and controlled experiments [40]. Having replicates enables an investigator to estimate this inherent variation in results [43]. Precise recording and measurement of data is also of great importance for ensuring the accuracy of results and the conclusions one draws from the results.

Report

Report in the final step of scientific stage is actually an official document that describes the whole process of scientific stage. It contain the specific process from the problem as background to empirical hypothesis that crystalize in controlled trial or experimentation until it gets the result [42,43,46]. All aspects of the progress until conclusion written in detailed report. It might also include recommendations for further research.

The purpose of a science report is to clearly communicate the key message regarding scientific findings; is it meaningful or not [47,48]. To fulfill this purpose, a clear explanation regarding problem as background, the hypothesis, the methodology, the result/findings and its interpretation must be delivered sequentially and gradually. This requires a clear link between the introduction and the analysis/discussion [11].

Science reports tend to have a more rigid and typical format than any other non-science reports. The unique format is calculated to clearly define the key message of the scientific stage [11,47,48]. It does this through indicating previously existing scientific process, the significance of the current scientific process conducted, the problem and or the hypothesis, what experimentation or trial was actually conducted, what data was collected and found, and finally the interpretation regarding what the findings mean and imply [47,48].

In the report section, the limitations of the process, both in terms of human resources and methods, must be clearly stated. this is the noble value of admitting human limitation from an evidence-based activity called the scientific stage [49,50]. By clearly stating this limitation, actually giving space for other scholars to study, explore and even improve deficiencies in the current scientific stages that have been carried out; this again shows the noble human value of sharing and collaborating [50].

Conclusion

Despite its rigid structure, the scientific stage still depends on the most human capabilities: creativity, imagination, and intelligence; and without these, it cannot exist [9]. That's why, no

matter how we try to use scientific approach in order to explain or answer a problem in life, it is our human limitations that make us realize that there will always be a gap between what is expected and the reality; and this is actually a blessing in disguise to be explored further.

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