

Chapter-18

Could a Doctral Thesis be a Research Lighthouse?

HR Ahmad, Satwat Hashmi

“What I think, I become.

What I feel, I attract.

What I imagine, I create.” ----- Buddha

How mankind survived through the Stone Age should be celebrated as a commendable feast of coping with natural challenges. Natural selection indeed enabled them to survive and reproduce (Charles Darwin, 1859).¹ What were the challenges? How did they solve problems? Challenges of survival were scarcity of food and security from wild predators. Since they had nothing, they had to do more thinking on how to become members of the predator family. They developed methods in the form of stone tools to be at the top of the food chain of predator and prey. If they would have not solved those fundamental problems of survival, they would have been extinct like dinosaurs. It was their developed 1200 cc homosapiens brain which came to their rescue (Alice Roberts, 2009).² Consequently, we all are here for over 40,000 plus generations (Carl Sagan, 2013).³ It was a commendable journey through different periods of ancient, medieval and modern, meandering from Stone Age tools to Large Hadrons Collider at the border of France and Switzerland. Five centuries after the last ice age, the natural and social sciences started evolving in various parts of the globe in response to myths and mythologies. Greeks stood out in the domains of creative thinking and experimentation with reference to the learning institutions of Ionians, Athens

and Alexandria. In the East, Chinese, Indians, Iranians, Middle Eastern and South Americans were holding the posts of learning according to their language and culture. An axis of mentors, learning institutions and disciples evolved and branched as driving forces for an evolution of a society (Roger C, 1969; Karl Popper 2013).^{4,5} Though the development of research based education has remained the domain of higher education despite the fact that the talent and passion for research appears in earlier age. The key for a research pathway is primarily the cycle of imagination and experimentation (Ahmad and Khan, 2017).⁶ This is independent of age, gender and culture across the globe.

The history of research shows two pathways. First one is a hypothesis based research in the form of an ‘answer’ to a question originating from an observation. This theoretical ‘answer’, however, has to be experimentally verified. If the hypothesis and experimental data match, it would yield a scientific conclusion. Second one is a non-hypothesis-based research. Here experimentation leads to data collection and analysis that can be explained with the lens of a hypothesis. The advantage of this data driven hypothesis is that it leads to a scientific theory. This in turn can become a law upon reproducible multiple observations. These two pathways are alternatively used in research (HK Kimelberg, 2004).⁷

Since imagination [brain] and experimentation [hands] are benchmark for artists and scientists, the horizontal enabling environment is the trigger to unfold their creative energy. Research mentors are like gardeners. They search for an environment with an analogy of good soil, light and wind corresponding to the mentor-mentee partnership, enlightenment to stimulate freedom of inquiry and critical thinking (Noam Chomsky, 1971, Bertrand Russell, 1961, Wilhelm von Humboldt, 1793).^{8,9,10} This critical thinking is especially true because science moves forward when it is challenged and falsified (Popper, 2013).⁵ The CVS model of Galen (129-207 AD) flew for centuries till it was shot down by Ibne Al-Nafis model of pulmonary circulation

in 13th century (Meyerhof 1935 and Qatayyah 1984).^{11,12} and Wilhelm Harvey functional model of general circulation in 16th century (Gordon 1991).¹³ It took another 100 years before blood pressure could be measured by Riva Rocci in 1896 and Korotkoff in 1905 (Verrij et al 2008).¹⁴ Whenever there is a gap between thinking and science, it can be bridged by development of a new methodology (Heidegger, 1952).¹⁵ Thus, a research activity revolves around on one of the planes of a new question with an old method or an old question with a new method or a new question with a new method. Like an artist who uses hands to paint or sculpture figurines, a scientist should use her/his hands to develop a method to answer a research query. A new method is thus like a new eye to provide evidence for a new interpretation of the existing scientific model or to replace it altogether. In this way, science moves forward and should be considered as a light for the enlightenment of humanity.

We would now deal with how to achieve it. One way of practicing is to follow a research pathway parallel or after graduate studies in a field of natural/social sciences to be conferred with a university degree MPhil leading to PhD Studies (Alguire et al 1994, Ahmad et al 2016).^{16,17} Alternatively; one can do life time research work through the means of grant and publication cycle but without acquiring any MPhil-PhD degrees (Bland and Ruffin, 1992).¹⁸ Another parallel Swedish model of doing research work alongside the formal education is based on publications in peer-reviewed journals with a high degree of critically analyzing editorial board (Hagen 2011).¹⁹ Thus research is usually driven through the axis of faculty, students and staff of an institution. Such an institution should hold together an infrastructure of research laboratory-offices, library and seminar rooms to brainstorm and debate leading to an exercise for the final use of how to defend a thesis. An institution is usually connected to many professional societies of natural and social sciences and humanities to present their first discovery report. The next connection is a journal which records the new discovery of science as means of communication to a scientific community and the public. In summary, the research firmament

should be populated by institutions, mentors and mentees, professional societies and journals like a Milky Way Galaxy.

Many Research pathways have evolved including an ingenuity model type of Steve Job and Bill Gate. Currently, we are walking mainly on the British curricular pathways following the signals from HEC and PMDC offices. Thus the research journey begins after 16 years of 'education'. HEC research flowchart streams from MPhil leading to PhD with a recommended allocation of credit hours for course and research work before the final day of defense of the thesis. Classically the thesis is presented in a monograph form. However, the modern Swedish cumulative model of thesis by publication is awaited with many advantages: publishing while studying, quality of publications and citations, research funding, post doc invitation, coauthor connectivity, learning to deal with unknown referees and maintaining the international standard of research and critiques (Ahmad 2016 and Ahmad et al 2017).^{20,21}

The question arises now as to how a mentor and a horizontal enabling environment can unfold the creative energy of a mentee. Two pathways could be pursued: a laboratory and a library research elective to hone hands on experience of methodologies and a literature survey on a topic of choice based on the mutual consensus of the mentor and mentee.

One of the following streams of research could be chosen:

1. Basic science unfolding a mechanism of a working model
2. Development of a new methodology
3. Diagnostic and Procedures
4. Therapeutic and Management
5. Molecular Epidemiology

The availability of internationally standardized research laboratories and active committed supervisors as a role model should enable to spark and nurture the spirit of free enquiry in mentees to do research work independently. The significance and importance of research in basic health sciences cannot be

overemphasized. It is rather the base of the clinical sciences. When a driver molecule of a mechanism of a normal function is not known, how then the clinical or applied science could ever move forward. There are many instances where the unfolding of a mechanism in cell and molecular biology awaits the development of a new methodology e.g. PCR technique allowing to make millions of copies of a scarce sample of DNA. It was discovered in 1985 and Nobel-prized in 1993 (KB Mullis).²² Since nature does not reveal her mysteries once and for all, the basic and methodology research requires a generation cycle of scientists. This in turn opens the gate way for research in diagnostic, therapeutic and epidemiology.

Research elective prepares MPhil and PhD candidates to defend their synopsis of the proposed work after thoroughly honing the thesis methodology and a literature survey with a critical review of references. This would mean that a well synopsed thesis is half done to kick start the work on an unknown terrain while keeping the tree and forest alternatively in view. The data from such a study can be presented either in a classical book form or in a form of modern cumulative thesis by publication. The blueprints of these two forms are shown in Table-I and II.

Table-I: Thesis in the form of a book

INTRODUCTION:	Literature review, identification of a problem, and aims and objectives.
METHODOLOGY:	Accuracy study, design, outcome variable and statistical analysis.
RESULTS:	Taking dictation from original recordings, tables and figures with legends.
DISCUSSION:	Critiques on methodology and study design important observations, interpretation and reasoning, stage debate with the data of a literature table and a working model of mechanism/s.
CONCLUSION:	Based on the strength of premises Implication for future research directions.
REFERENCES:	Widely read and critically analyzed.

Table-II: The Cumulative Thesis Work

1. Synopsis	Research work road map.
2. Publications	Peer reviewed international journals.
3. Summary	Publications connectivity to the topic of thesis.
4. Acknowledgment	Mentors, faculty and staff.

Another type is a cumulative thesis by means of publication. It started from Sweden and now is popular semi-globally (Hagen 2011).¹⁹ Usually a thesis work has a few divisions as a function of time line. It enables to publish parallel to ongoing research work as the data for a publication is ready. In a way, it becomes an aerobic exercise of harvesting data and publishing hot from the lab. As the threshold of publications reaches its level, the defense day would be on the horizon. Thus this mode of thesis has the advantage of being doubly refereed by the cutting edge journals of the given field and the faculty of health sciences. It is supplemented by a lucid summary showing an integration of publications around the thesis topic. If coauthors are on publication, a declaration needs to be given about the sharing proportionality of experimentation, data analysis, and interpretation of findings, modeling, writing and editing the manuscripts before submission to journals. A report should also be prepared on how the principle author critically interacted with unknown reviewers of journals. The weightage should be tilted toward the thesis candidate so that it can ethically be defended before the team of august research faculty. Good interaction with unknown referees is a challenging means of certification of originality and impact of research work of the candidate MPhil/PhD.

The scientific draft of a thesis or a publication is internationally approved and framed in components as shown in table 1 (Ahmad, 2016).¹⁷ Introduction deals with the background literature of a synopsis to show the origin of the research queries of the proposed study. One stream could be from the gaps in the literature where the mechanisms and models are not completely elucidated. The second stream could be from

unexplainable observations from laboratory, ward or field. The third stream is indeed challenging when one is motivated to take the responsibility of developing a new method. It is painful and depressive pathway of research but when it clicks one becomes a star scientist overnight. The fourth stream could be when an existing model of mechanism is shot down by new and convincing evidence of data. The fifth stream deals with the mathematical modeling from the literature data. It would facilitate drafting the introduction portion if a mini-review article related to the topic of thesis could be published. The abridgment of a review article with a literature table and a model of mechanisms could thus become an ideal part of the introduction. The candidate must have a 'radar' system to scan publications related to the thesis work like a watch guard on the stock market. This exercise would guard the originality of the thesis work. The aims as ends and objectives as means should be placed at the end of the introduction. Aims could be addressed in the form of research questions. The objectives deal with how to achieve the aims of the proposed study.

The next part deals with the **methodology** and the study design. This section could be considered as a motor of the thesis work. The accurate study of the methodology is imperative in context of reliability, reproducibility, sensitivity and specificity. Control your controls is the best guide for a precise and authentic work while adapting personally to working in a lab. The study design should be done in context of in vivo or in vitro experimentation. It should describe about species, numbers, age, weight and essential anthropometric parameters. Types of surgical procedures and anesthesia if applied should be included along with a detailed description and quality control of methodology. Continuous record of variables should be preferred to static one to harvest the fruits of transients. The experimental protocol should be designed after a small pilot study especially when dealing with a human study. A detailed and a well thought experimental protocol forms the basis of experimental conditions under which the results are to be harvested. One should be cautious that any deviation from the

protocol would affect the outcome as well as the interpretation of results. Thus the experimental boundary conditions are to be highly respected. The different parts and phases of experimental protocol should be schematically diagrammed. It should show measured parameters, time period, intervention on and off arrows, and the thoughtful selection of statistical processing of data. The writing of a thesis is facilitated when the results are all well lucidly transformed into tables, figures, original recordings, schematic diagrams of methods and protocols.

The **results** of a thesis should be treated like a bride or bridegroom. This promotes the train of thoughts required to critically analyse the data in a quantitative/qualitative fashion depending upon the type of study. The golden rule of writing results is to simply take a dictation from the tables and figures of an experimental work. No explanation is required. Before writing one should observe each table and each figure for some time to make a list of observations in the form of key words. The more one has understood the information content of a diagram; the better will be the fluency of writing. The statistical processing of data ensures whether the results are by chance or not by chance being judged by the uncertainty value known as sigma (Carroll, 2013).²³ The sigma value quantifies how suspicious one should be to rule out the opposition of the null hypothesis provided the methodology of a study is fair. In addition, the effect of an intervention should be tested for its validity, reliability, precision and significance. The legend of a figure should be well composed. It should contain a title, a brief description of the stimulus-response, the cardinal effect, and a concluding remark. The writing of thesis is further eased by a well maintained registry of data in the form of a log book, original recordings, critically analyzed references with summaries and the master plan sheet containing the virgin data of the thesis to understand the original signals before submitting to the procedures of statistics. The original data are institutionally archived and should be preserved for seven good years after the work has been published.

Discussion is the liveliest part of a thesis. It is aimed to stage a constructive debate with unknown authors from literature. The golden rule of such a debate should be that a rigid explanation looks backward but a design looks forward to make a new model out of the thesis and literature data. Of course, it should be designed in such way that the data could be objectively discussed and interpreted. Agreement and disagreement can be resolved with consensus if one could consider under which experimental conditions the results were obtained by various authors. It means that the boundary conditions for each result should be carefully analyzed and compared. Now the discussion could be divided into the following components:

1. Critique of methodology and experimental boundary condition.
2. A list of evidence based observations.
3. Interpretation and comparison of results using a literature table.
4. Designing of a working model of elucidated mechanisms.
5. Premises based conclusions.
6. Evidence of first report.
7. Future research directions.

The criticism of the methodology and the study design enables a candidate to demonstrate how precisely the research work has been accomplished. What are the experimental boundary conditions of results? How many thesis queries could be answered? What new queries emerged from these studies? Since the interpretation of results critically depends on the experimental protocol and methodology, inferring epidemiological study from a patient- and a general- population could be dicey in context of how a result from hospital could be applied to the whole population.

After having defined the experimental conditions under which the data have been harvested, one should make a list of important observations of the present study. This may form

an agenda to initiate interpretation, argument, reasoning and comparison of data with the literature. The outcome of this constructive debate should enable the candidate to design a working model in the form of a block diagram revealing the current level of understanding. All statements should be well referenced after a critical analysis of the experimental boundary conditions. It is always challenging to compare one study from another because of varying experimental protocols. On the other hand, a same effect can also be demonstrated using different methods. A good example is that of nitric oxide discovery as a gaseous signaling molecule regulating the microcirculation. For this work, RF Furchgotts, LJ Ignarro and F Murad shared a Nobel Prize in 1998. Most of the processes underlying a mechanism can be understood, if the time course of the variable in response to a stimulus is known. Thus, the dynamic aspect of interpretation of result is sought in comparison to a static measurement. Therefore, a continuous record of variables should be preferred. It reveals the secrets hidden in the transient and steady states in order to unfold the mystery of an unknown mechanism of working. This in turn leads to a new state of the art modeling (Ahmad and Loeschcke 1982).²⁴

Finally, the discussion-debate should conclude on how far the study was successful in answering the research questions of this thesis. Usually, it raises more questions than it answers. In this way, it becomes a life time engagement for a committed laboratory scientist to sow new seeds to harvest fruits of the spirit of free enquiry and critical thinking. Also it is important to note that science moves forward when it is quantifiable and falsifiable and thereby not to lose the spirit and fragrance of scientific inquiry. The authors claim of the first report is finally acknowledged by the level of critiques and the critical review of her/his research work by the literature. It can be read by a high rate of citation index of a publication. However, it all takes time to mature after a critical mass of critiques and reproducibility of data.

In summary, the research moves in three directions. Firstly, it answers your long awaited queries partly in 'yes' and partly

in ‘new questions’. Secondly, the work, as it is, should be disseminated through a thesis monograph or better a thesis by publications mode. Thirdly, a successful defense of a thesis enables you to celebrate the Master of Philosophy or Doctor of Philosophy degree in the field of your choice to become a mentor to drive the generation cycle of an institution. Thus, science is a light serving humanity but with an intellectual honesty. It is achieved only in an enabling environment, where there is freedom of inquiry and critical thinking originating from “I know what I do not know” according to Socrates. Fulfilling these criteria of science, a thesis can become a research lighthouse as a source of enlightenment while shying away from the limelight. In this context, a family state can rise up to become a nation state based on a cutting edge blend of technical and higher education and the meritocracy as two engines of economy according to the Lee Kuan Yew’s model (LK Yew 2012, Eric Hobsbawm, 1975).^{25,26}

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1. HR Ahmad, MD, PhD [Bochum], FCPS.
Professor of Physiology,
E-mail: hrahmad.alrazi@aku.edu
 2. Satwat Hashmi, MBBS, MS, PhD.
Assistant Professor,
E-mail: satwat.hashmi@aku.edu
- 1-2: Department of Biological and Biomedical Sciences,
Aga Khan University,
Karachi, Pakistan.