

MODULE 1

INTRODUCTION TO RESEARCH

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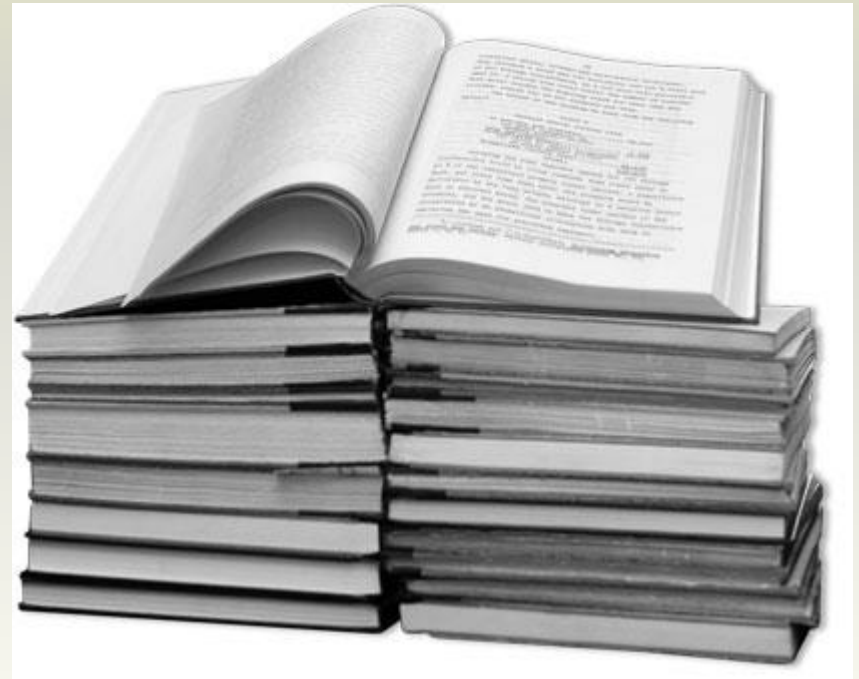
Course Learning Outcome

- Able to comprehend the process of conducting academic research
- Able to identify and formulate research problem by critically analysis of current research papers
- Able to design suitable techniques/methodology for proposed research
- Able to write and present research proposal/thesis

Outline

- About the course
- What is research
- Research in Computer Science
- Training to become a Researcher
- Expectation of a PhD research

About the Course



Audience of Class

- Doctor of Philosophy (Computer Science)
- Master of Science (Computer Science) (by research)



Class Schedule

DATE	DAY	TIME	VENUE	MODULES
5 April 2015	Sunday	9.00am -12.00pm	Seminar Hall, Block N28a	Introduction to Research
		2.00pm - 5.00pm		Problem Formulation
6 April 2015	Monday	9.00am -12.00pm	Seminar Hall, Block N28a	Literature Review
		2.00pm - 5.00pm	Teaching Lab 1, N28a	Library Search
7 April 2015	Tuesday	9.00am -12.00pm	Seminar Hall, Block N28a	Research Methodology & Design
		2.00pm - 5.00pm		Qualitative Research Methods & Techniques
8 April 2015	Wednesday	9.00am -12.00pm	Seminar Hall, Block N28a	Empirical Methods & Quantitative Data Analysis
		2.00pm - 5.00pm		Thesis & paper Writing
9 April 2015	Thursday	9.00am -12.00pm	Seminar Hall, Block N28a	Research Evaluation & Thesis Examination
		2.00pm - 3.30pm		Research Process & Management
10 th May 2015	Sunday	9.00am – 5.00pm	Academic Office, Level 3 N28a	Proposal Submission

Note on Class Attendance

- Class attendance must be at least 80%. Please note that if you miss class, then you need to take the whole course again.
- If you have something else to do, eg. First assessment, IDB interview, you need to give me the hardcopy evidence that you need to skip a module of the class.
 - However if you miss more than one module (< 80% attendance) you still need to repeat the course
- Please sign for attendance during every session.
- Please write your semester number in the attendance list.
- Please be punctual for all classes.

Other Evaluation

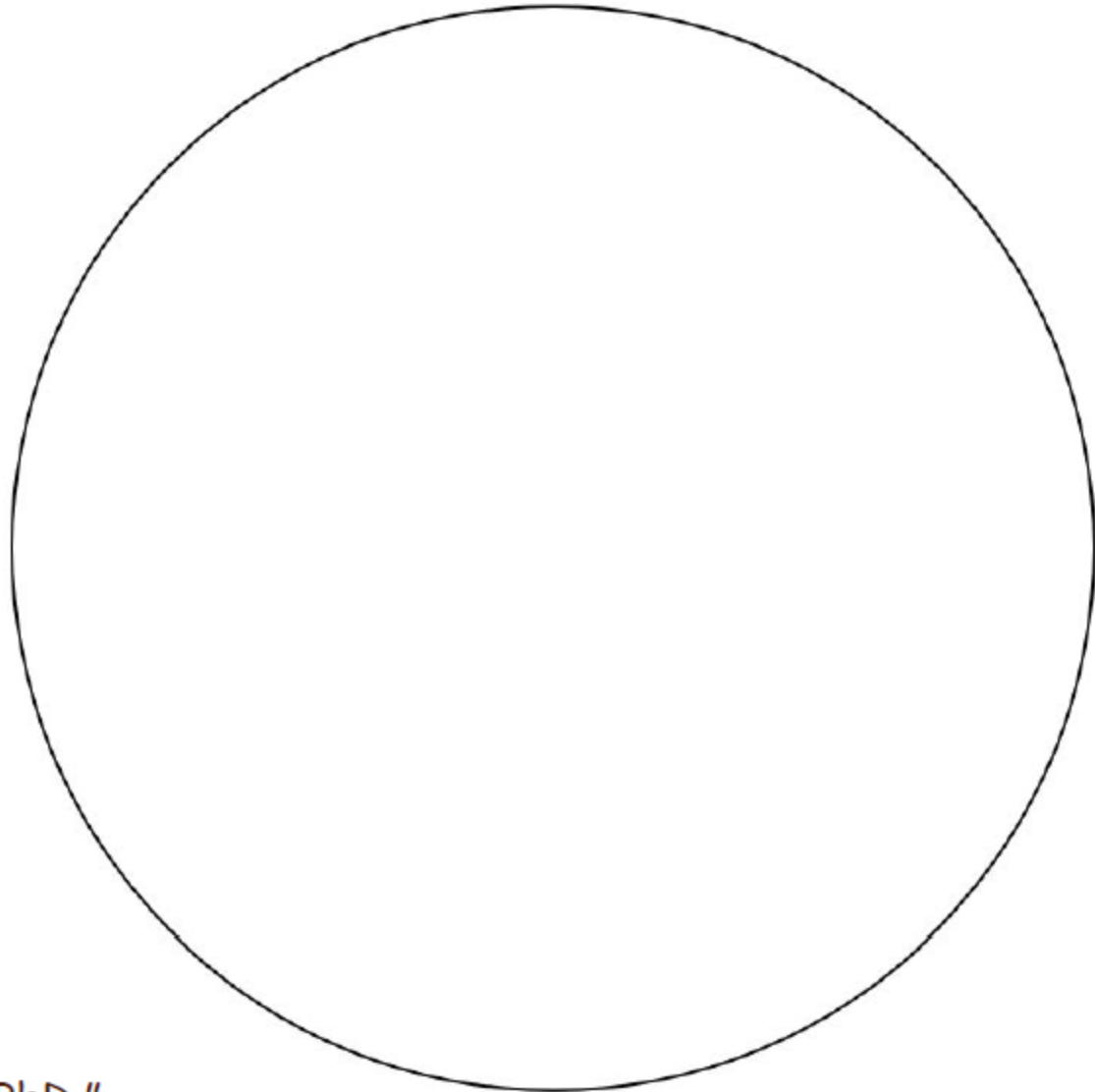
- Hardcopy of Proposal
 - Latest by 10th May 2015
 - Send to Norshahida (Shasha), Academic Office, Level 3, Block N28A
 - Maximum 50 pages
 - For Writing Guidelines, refer to:
<http://sps.utm.my/sps/images/academicresources/UTM%20Thesis%20Manual%202007.pdf>
 - For content, please refer to Module on Thesis Writing

Introduction

- PhD is the highest academic degree anyone can earn.
- Requires extended study and intense intellectual effort
- To earn a Ph.D., one must accomplish two things
 - **Master** a specific subject completely
 - **Extend** the body of knowledge about that subject

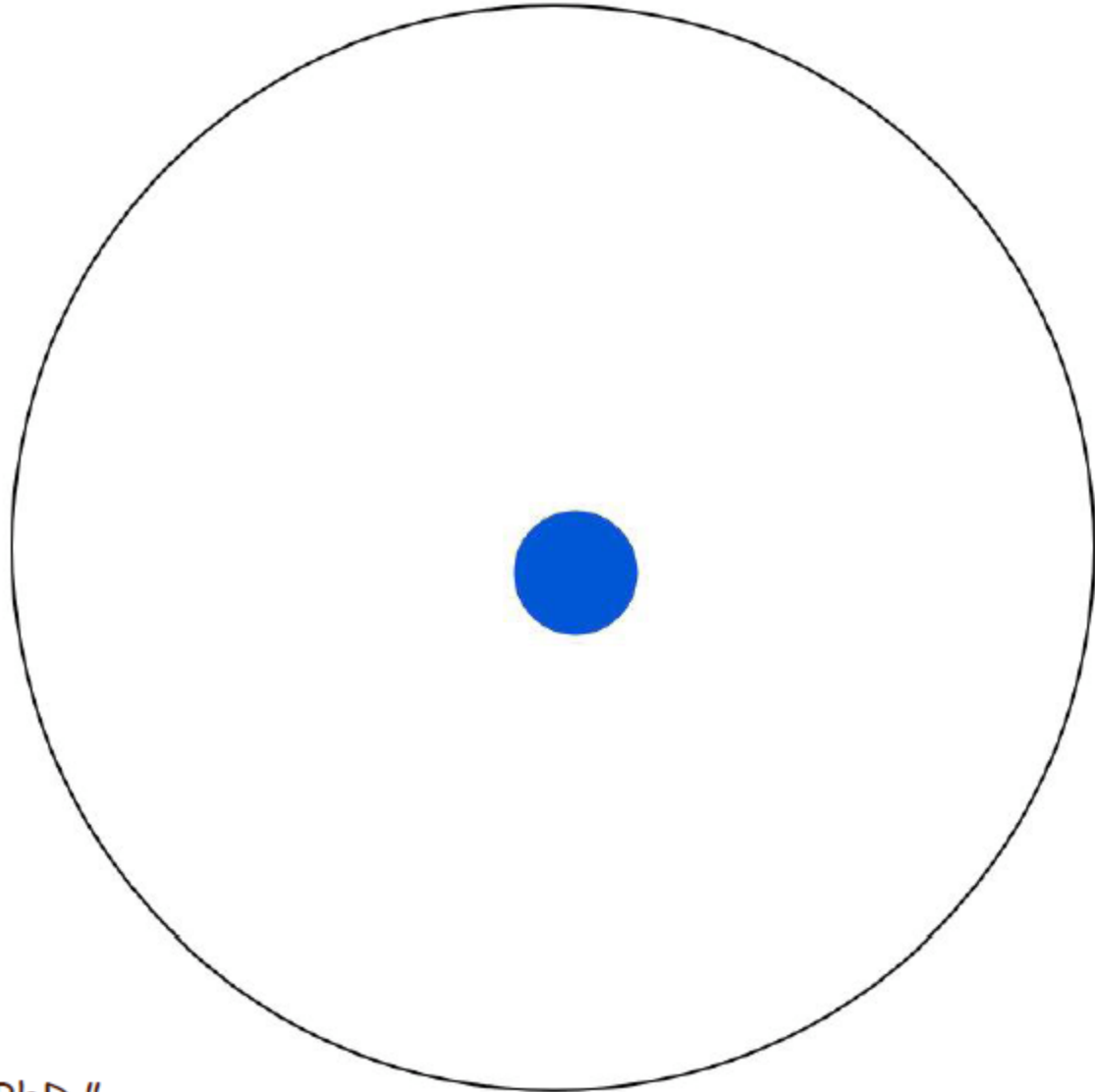


Circle Contains All Human Knowledge



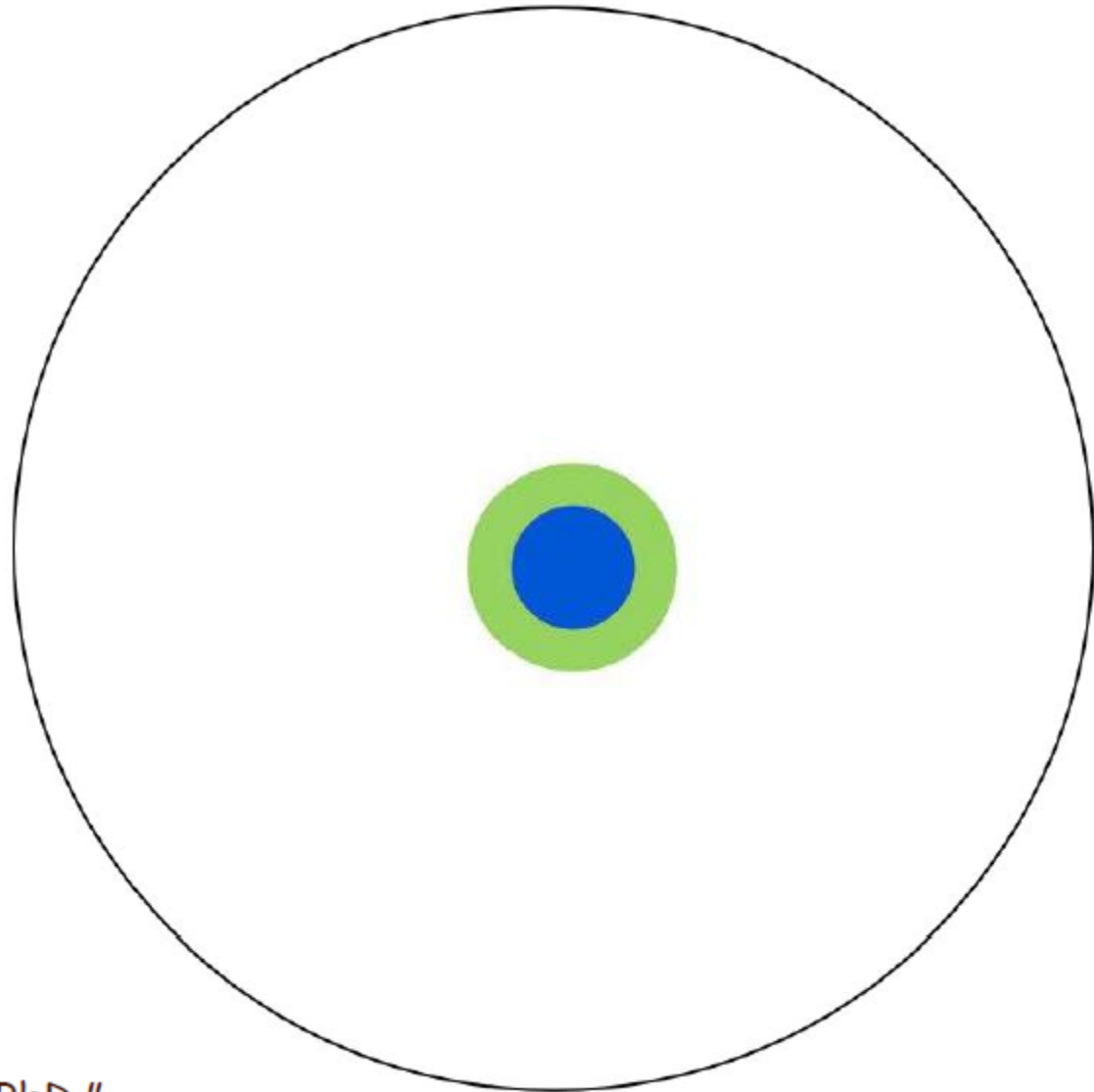
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Illustrated Guide to a PhD."

When you finish primary school



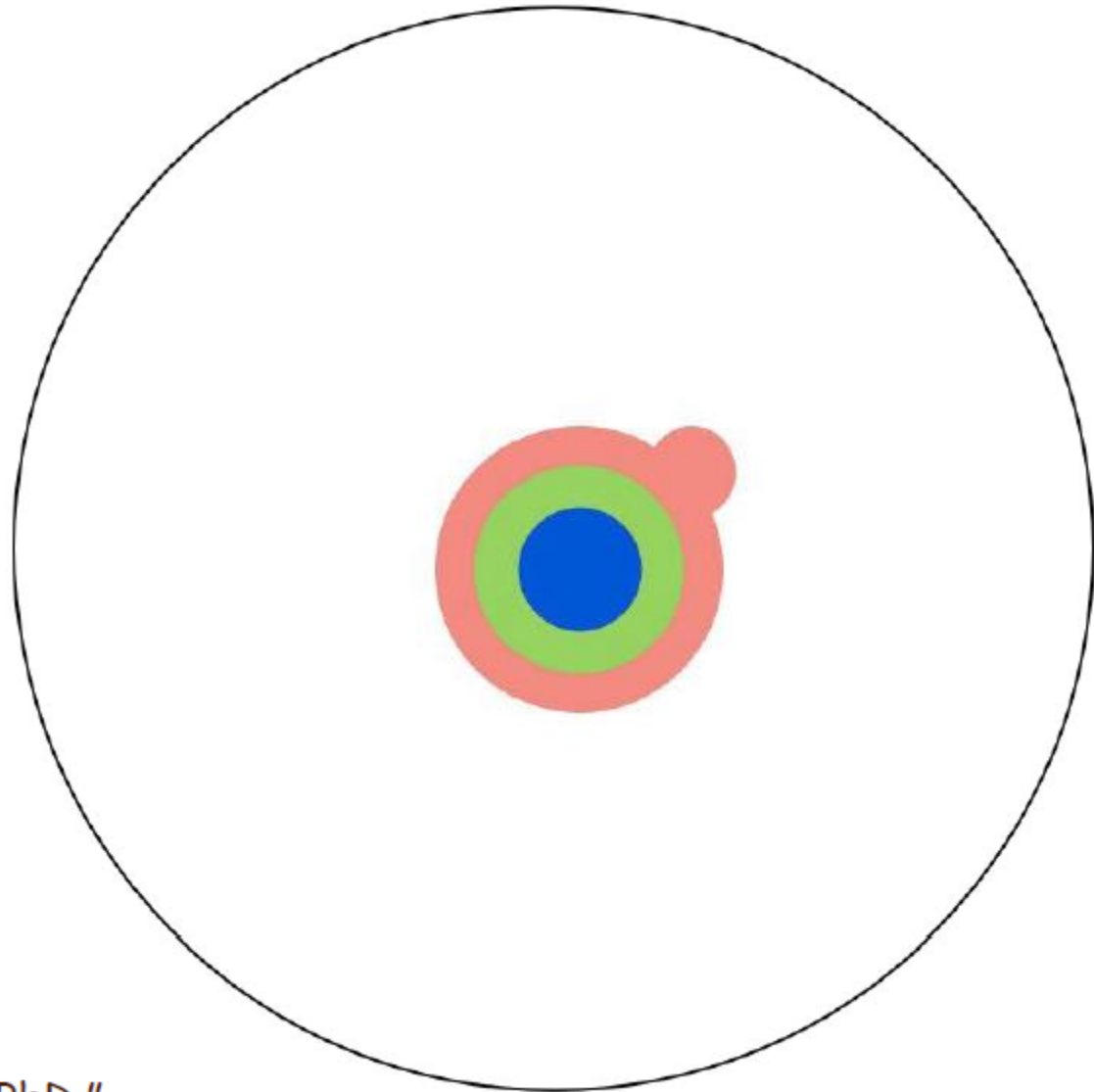
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When you finish secondary



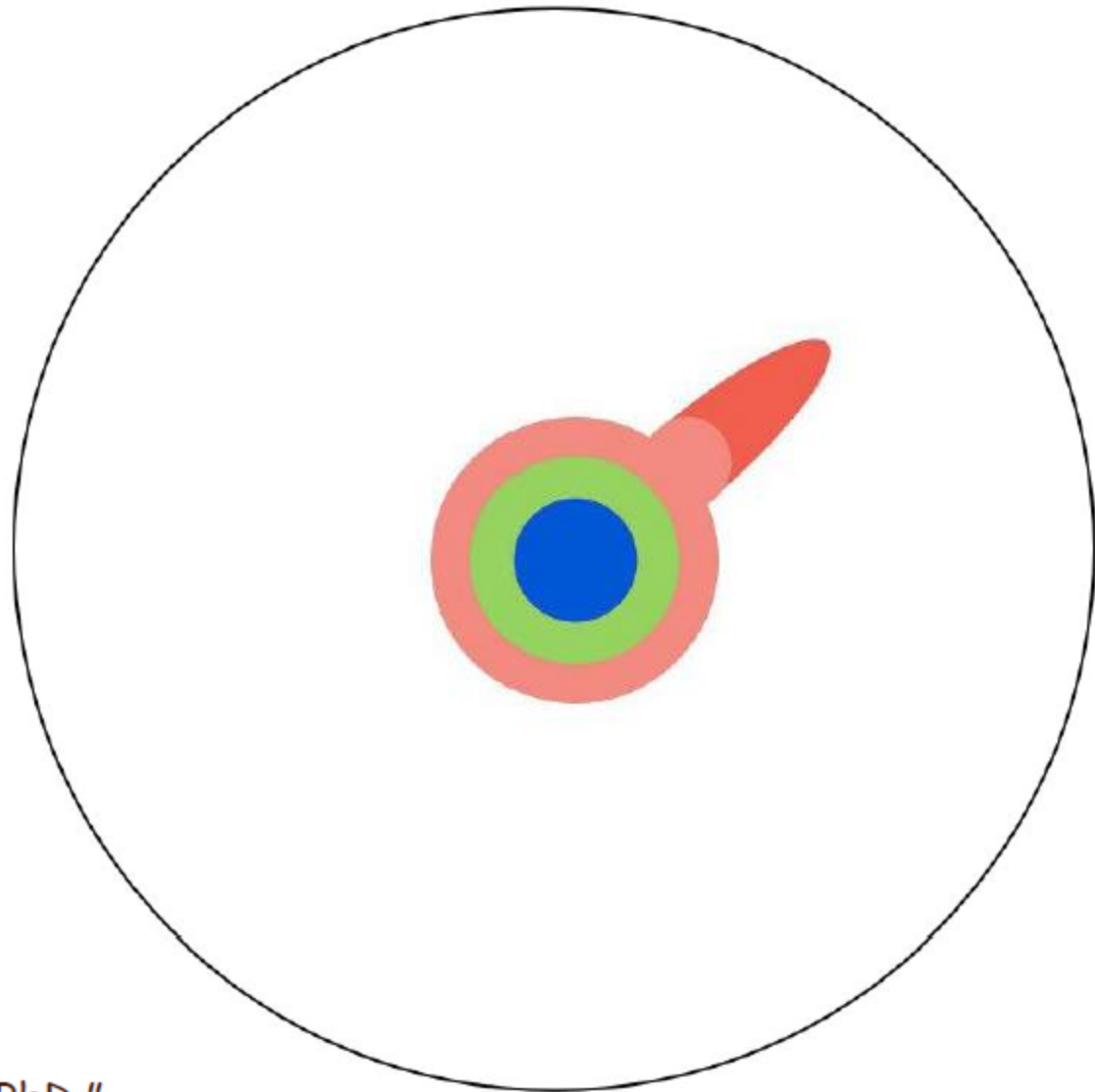
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When you finish undergrad



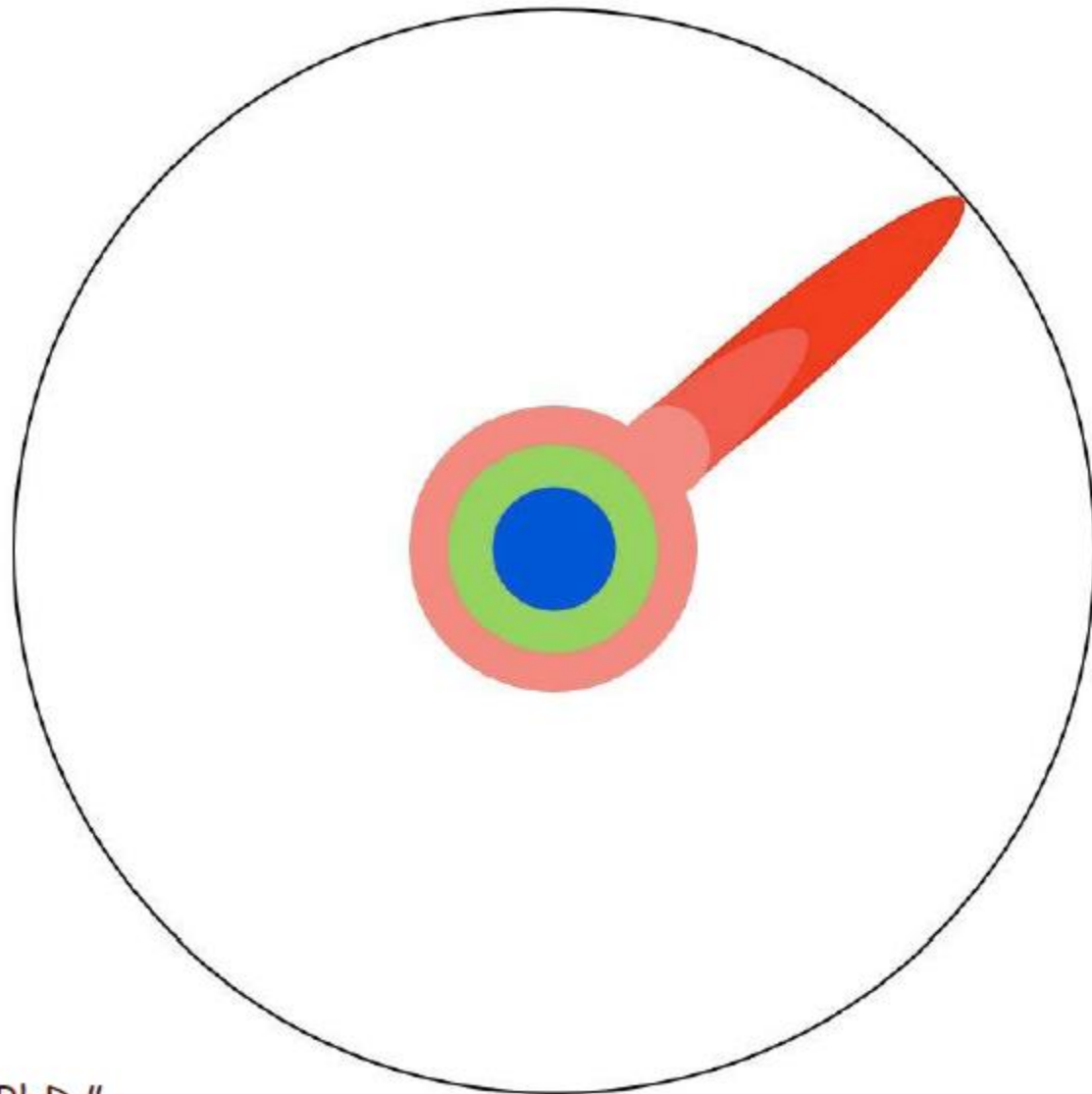
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When you finish a Master's



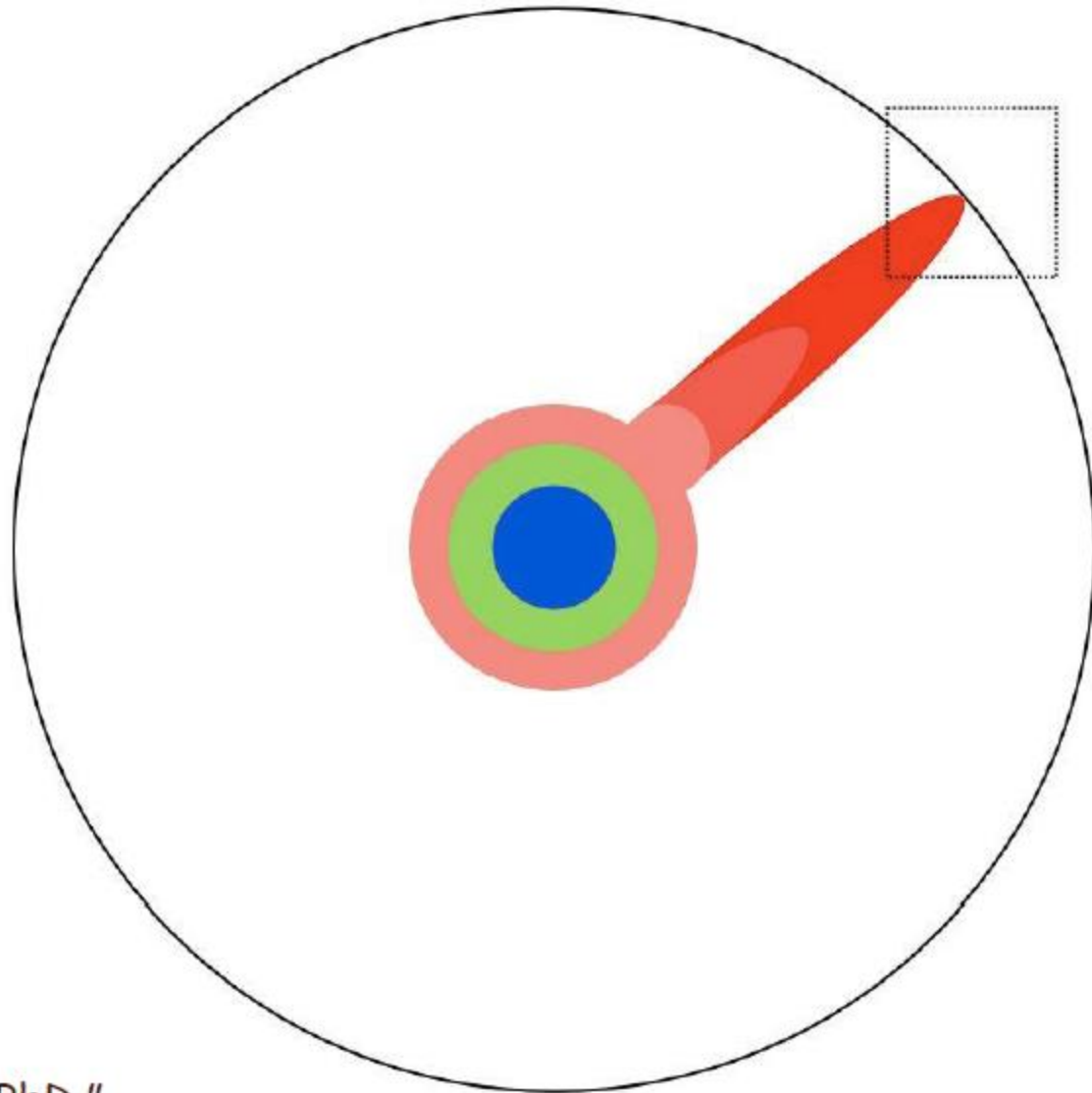
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Reading research papers takes you to the edge



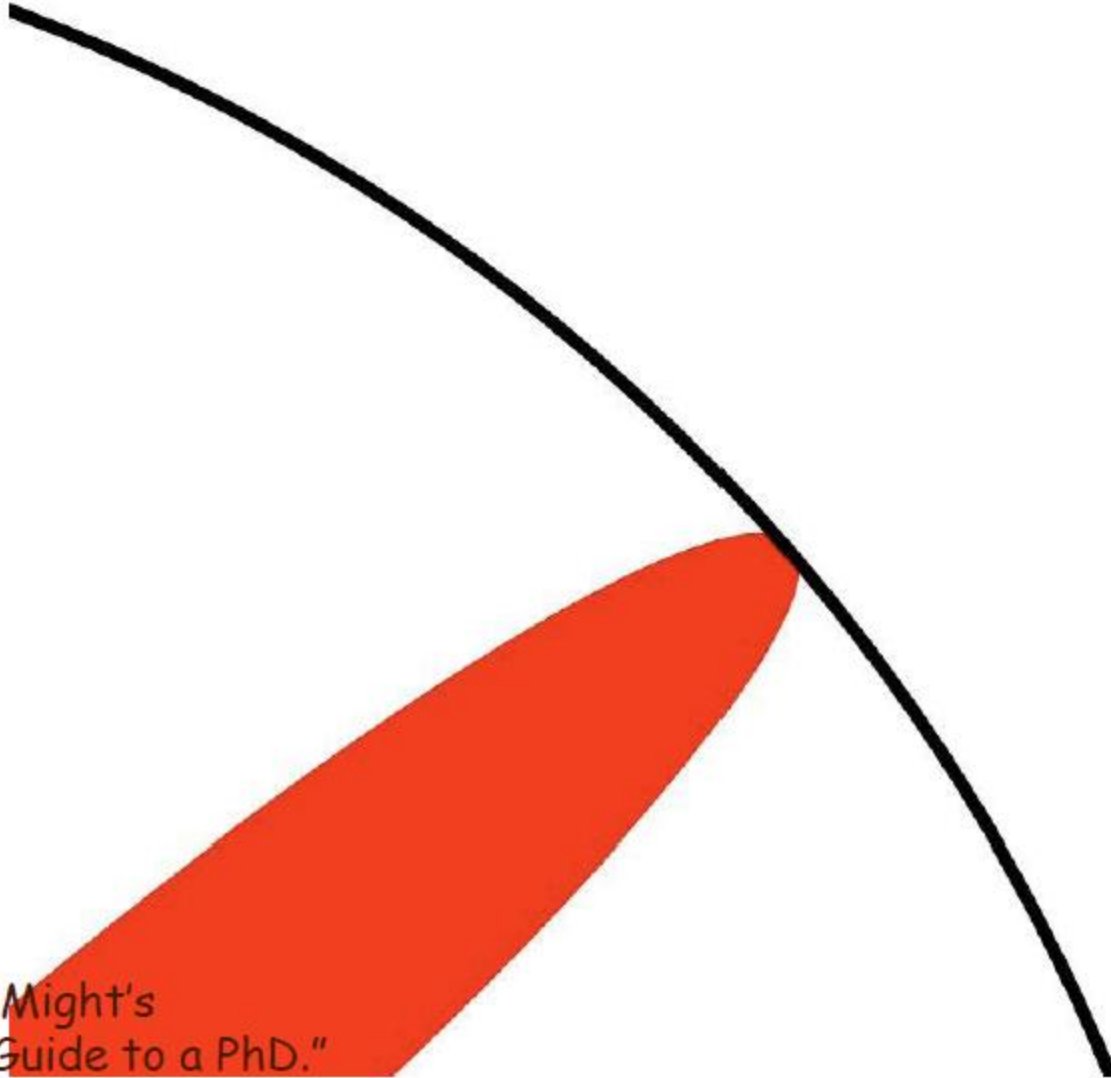
From "Matt Might's
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At the boundary, you focus



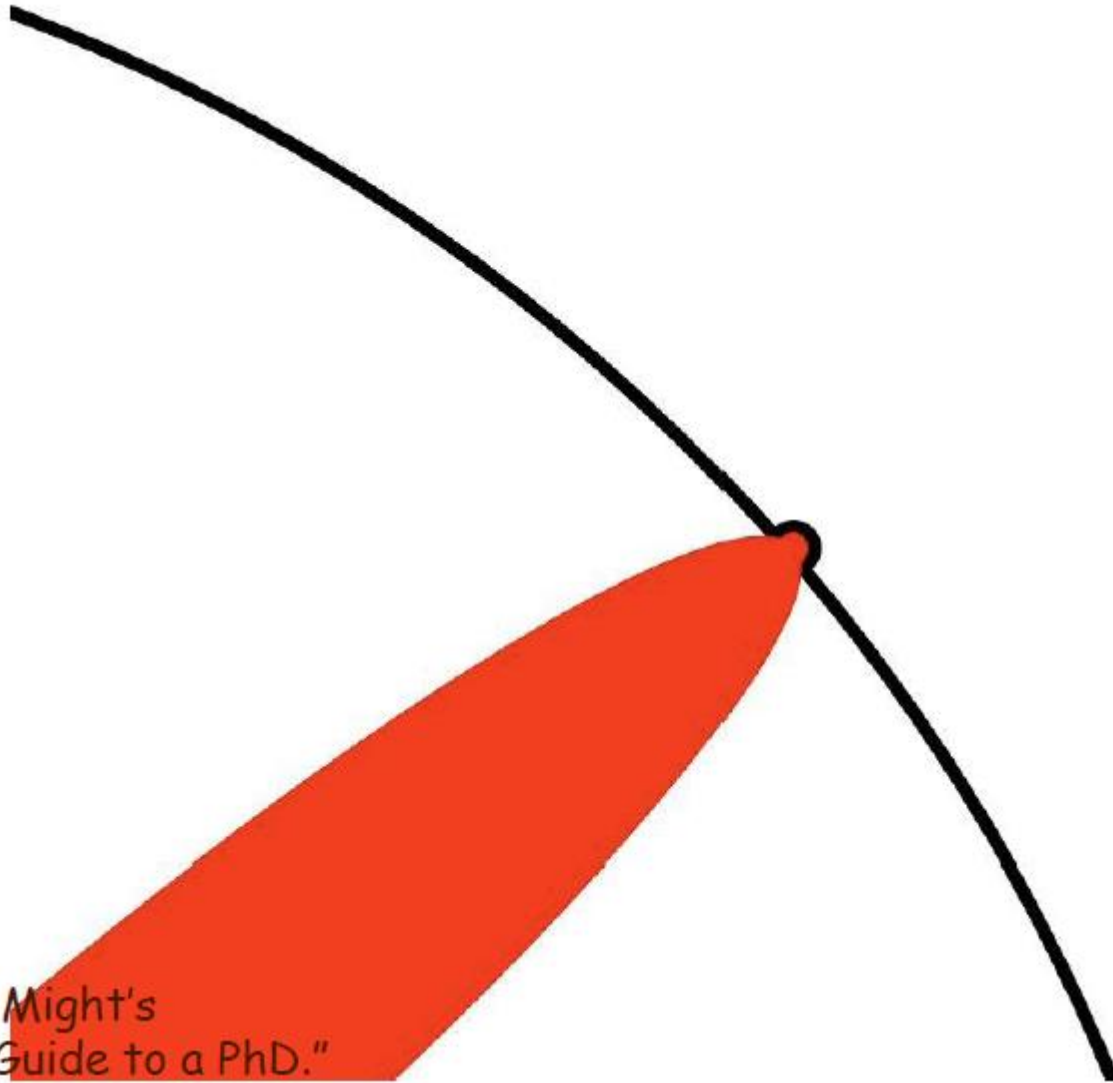
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You push at the boundary for several years...



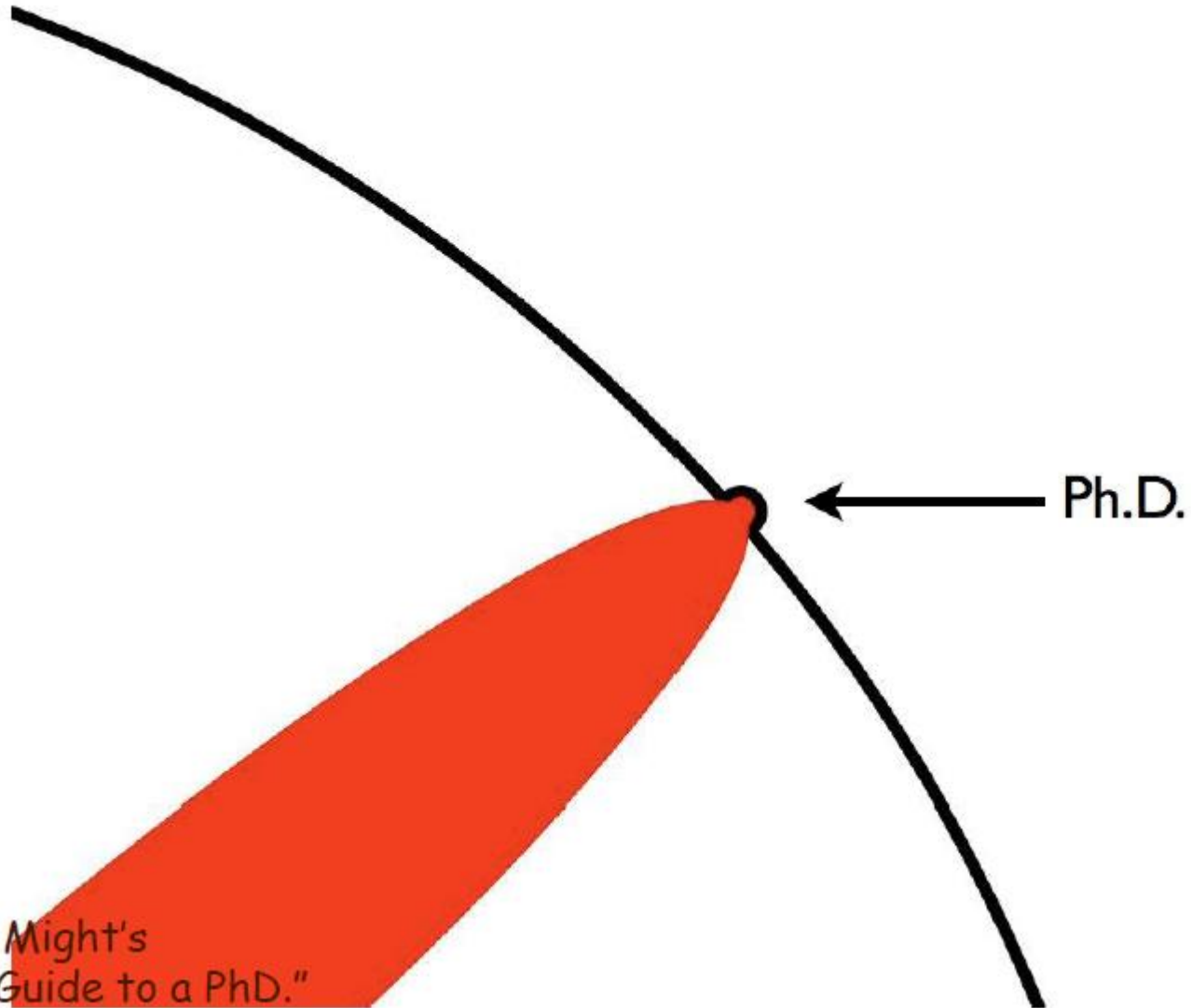
From "Matt Might's
Illustrated Guide to a PhD."

One day, the boundary gives way



From "Matt Might's
Illustrated Guide to a PhD."

That dent is your PhD



From "Matt Might's
Illustrated Guide to a PhD."

PhD by Phillips and Pugh (1994)

Doctorate is recognition that the holder is a fully **professional researcher**, meaning that they can do the following:

- Can produce **research** that is of interest to other professional researchers.
- Have a **command of the subject** to the extent that they **can evaluate** the work of other researchers.
- Are astute enough to identify where they can make a useful **contribution**.
- Are able to **communicate** their results at a level that is appropriate to an audience of professional researchers.

PhD degree by Malaysian Qualifications Framework (<http://www.mqa.gov.my/>)

Conferred to students with abilities to conduct **independent research** :

- show systematic **comprehension and in depth understanding** of a discipline and **mastery of skills and research methods** related to the field of study;
- show capabilities to generate, design, implement and adopt the integral part of **research** process with **scholarly strength**;
- make **critical analysis, evaluation and synthesis** of new and complex ideas;
- **communicate** with peers, scholarly communities and society at large concerning the field of expertise; and
- **promote the technology, social and cultural progress** in a knowledge based society in the academic and professional contexts.

PhD CS

Programme Objectives

- To produce students who are **experts in their related fields** and are able to **work independently** with supervision from highly qualified supervisors.
- To produce students who are **very knowledgeable and theoretically sound** and are **able to apply these for the analysis and solution of problems** where these leads to new or substantially improved insights and performances.
- To produce students who can **think critically and creatively** thus capable of generating and developing new knowledge, products, materials or methods for the benefits of mankind.
- To produce students with **excellent communication skills**, capable of communicating effectively both technically and theoretically in various context and with various related parties, thus sharing new knowledge with other researchers from other institutions, universities and also industrialists.
- To produce students who can **adapt to changes in environment** and **practice life long learning**.
- To produce students with **high integrity** and who are **ethically professional**.

Duration of Study

	Full time		Part time	
	Min. (registered semester)	Max.	Min. (registered semester)	Max.
Master	2 (1 year)	6 (3 years)	4 (2 years)	8 (4 years)
Ph.D.	6 (3 years)	12 (6 years)	8 (4 years)	16 (8 years)

Early Submission

- *A doctoral degree student who has successfully published two papers in internationally refereed journals may submit his/her thesis after completing a duration of 2 years (FT) or 3 years (PT)*

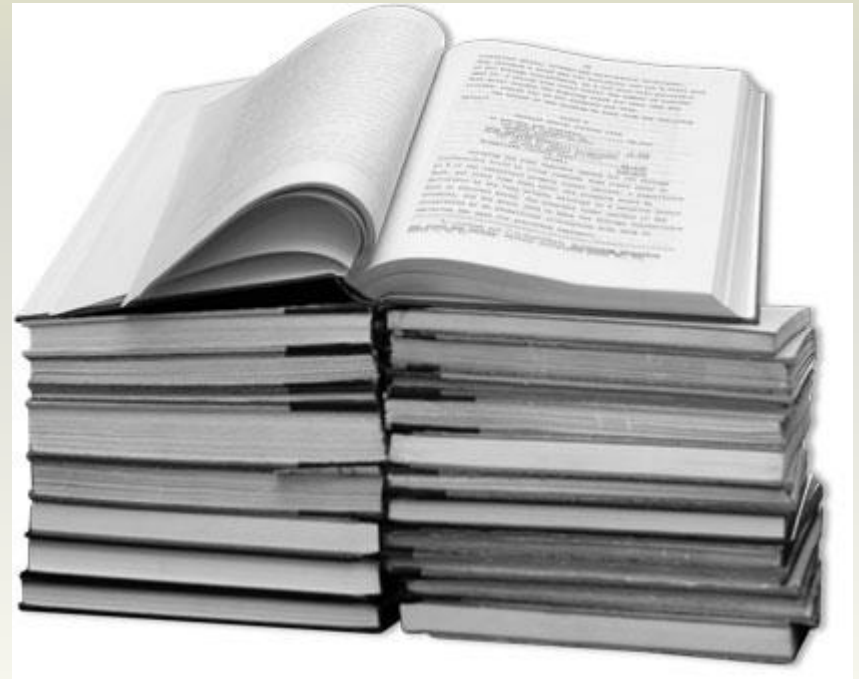
Duration and Paper Requirements

Minimum Duration	Terms & Condition
18 months	3 refereed journal, CIF ≥ 9
24 months	2 refereed journal, CIF ≥ 6
30 months	1 refereed journal, CIF ≥ 3
36 months	1 refereed, indexed journal

Conventional PhD

- *For candidates who have fulfilled the **conventional 36 months**, candidate is required to have published at least ONE (1) refereed and indexed journal article prior to **submission of thesis** for examination and viva-voce.*

What is Research?



What is Research?

Research is a human activity based on intellectual investigation and aimed at **discovering, interpreting, and revising** human knowledge on different aspects of the world.

Research is the method used to **accumulate scientific knowledge**.

Roscoe, J.T. (1975)

Research

(Howard and Sharp, 1983)

- Seeking through methodological processes to add to existing body of knowledge and, hopefully to that of others, by the discovery of non-trivial facts and insights
- Based on intellectual investigation and aimed at discovering, interpreting, and revising human knowledge on different aspects of the world

Research – What?

- Research is the way in which
 - Ideas (or hypothesis) are generated
 - And then how the ideas are treated
 - Hunting for facts or truth about a subject
- Research is a **systematic search** for **new knowledge**
- Research is an **organized scientific investigation** to solve problems, test hypotheses, develop or invent new products
- Research can use the scientific method, but need not do so.

Research Definitions

Research is an organized, systematic, data-based, critical, scientific inquiry of investigation into a specific problem, undertaken with the objective of finding solutions to it.

Its function is to understand the study & to communicate it with others

A research project has a well-known structure a beginning, middle and end.

Researchers know the aims of research and exactly what is to happen

Rarely produce surprise

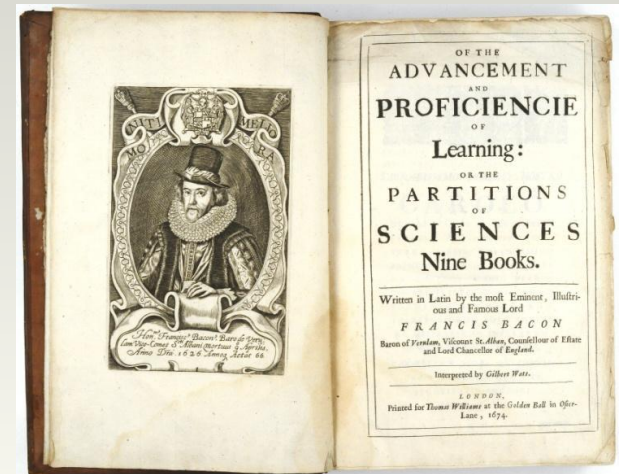
What is Science

- From Latin
 - scientia, "knowledge"
- Builds and organizes knowledge in the form of testable explanations and predictions about the world we live in.



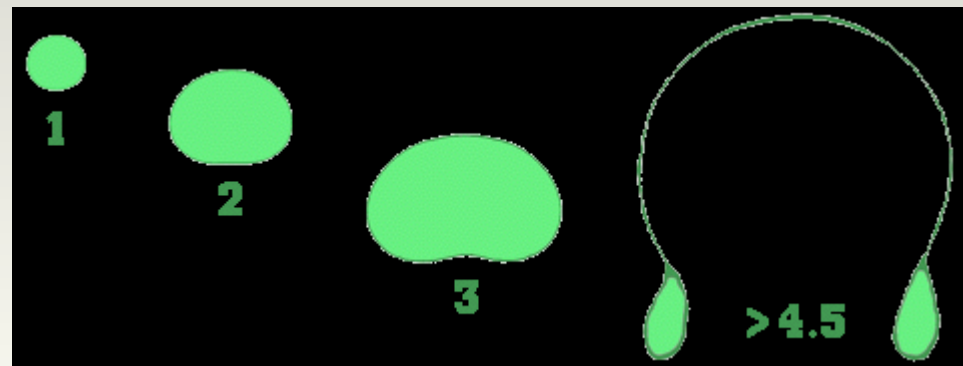
Galileo

Bacon



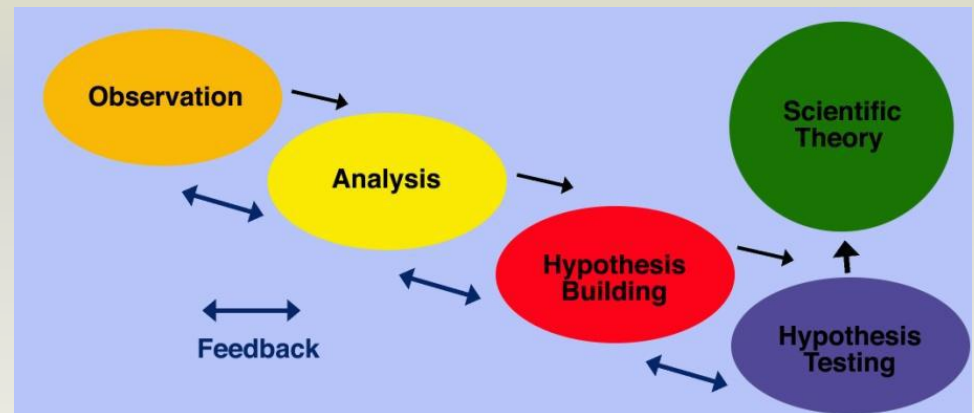
Things that are not obvious

- Research exposes the world
- Investigate for the purpose of
 - Discovering something new
 - Interpreting something not understood
 - Revising something wrong or incomplete



What is the Scientific Method?

- 1 Formulation, testing, and modification of hypotheses
- Systematic
 - observation,
 - measurement, and
 - experiment,



1 Oxford English Dictionary

2 Indiana University

Research – Scientific Method

- Observation
 - A general problem area (research topic) is defined
 - Then pertinent observations are made via literature review, discussions and experiments
- Problem Definition
 - From the observations, specific questions are asked
 - And the problem to be addressed is defined
- Hypothesis Generation
 - From the questions asked, researcher makes a specific guess or provide an idea about what is going on.
 - Objectives are defined
 - Appropriate methods are selected for testing

Research – Scientific Method (...Cont)

- Testing
 - Hypothesis is tested through experiment
 - Data are collected, analyzed and interpreted
- Research Evidence
 - Hypothesis accepted/rejected or modified
 - Conclusion is made

Example of Research

- A general manager of a car producing company was concerned with the complaints received from the car users that the car they produce have some problems with rating sound at the dash board and the rear passenger seat after few thousand kilometers of driving. (**Observation of a Problem**)
- He obtained information from the company workers to identify the various factors influencing the problem. (**Problem Definition**)
- He then formulated the problem and generated guesses (**hypotheses**).
- He constructed a checklist and obtained requisite information from a representative sample of cars. (**Testing : Data Collection**)
- He analyzed the data thus collected, interpreted the results in the light of his hypotheses (**Testing**) and reached conclusions.

Important Characteristic of Research

- Systematic
 - Work in a sequence of steps which were in order and thus systematic
 - Order: Observation, Problem Definition, Hypothesis, Testing, Conclusion
- Follows a scientific method of enquiry
 - Researcher should not just jump at the conclusions,
 - But used a scientific method of enquiry in reaching conclusion

What Research is NOT?

- Research is not information gathering
 - Gathering information from resources such as books or magazines.
 - No contribution to new knowledge
- Research is not the transformation of facts
 - No contribution to new knowledge although this might make knowledge more accessible.

Research is NOT a SIMPLE Linear Activity

- Never more in a straight line.
- Always loops back & forth.
- Manage the parts in order to manage the whole.
- Searching for something you won't know until you find it.
- Nobody can solve the world's great problems in a tiny project.

Characteristics of High Quality Research

- It is based on the work of others.
- It can be replicated (duplicated).
- It is generalizable to other settings.
- It is based on some logical rationale and tied to theory.
- It is doable!
- It generates new questions or is cyclical in nature.
- It is an activity that should be undertaken for the betterment of society

Bad Research

- The opposites of what have been discussed.
- **Plagiarizing** other people's work.
- **Falsifying data** to prove a point.
- **Misrepresenting** information and misleading participants.

Research – Why?

- Why one do research?
- Research is discovery.....discovery is an exciting endeavour or adventure
- “The discovery (inspiration – 1%) makes the endeavour (perspiration – 99%) worth the effort”

Research – Why?

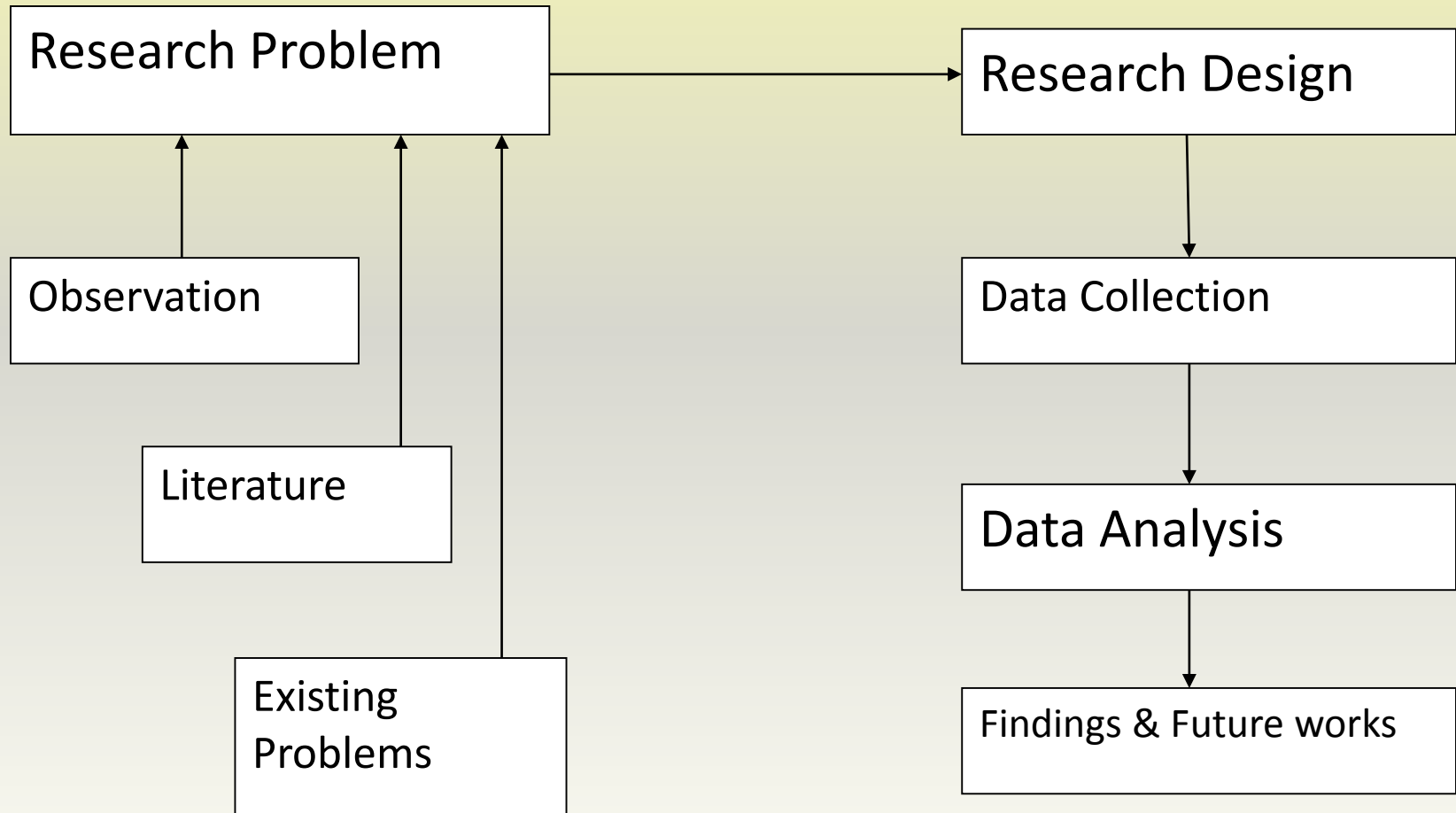
- Desire to get a research degree along with its consequential benefits
- Desire to face the challenge in solving the unsolved problems
- Desire to get intellectual joy of doing some creative work
- Desire to be of service to society
- Desire to get respectability



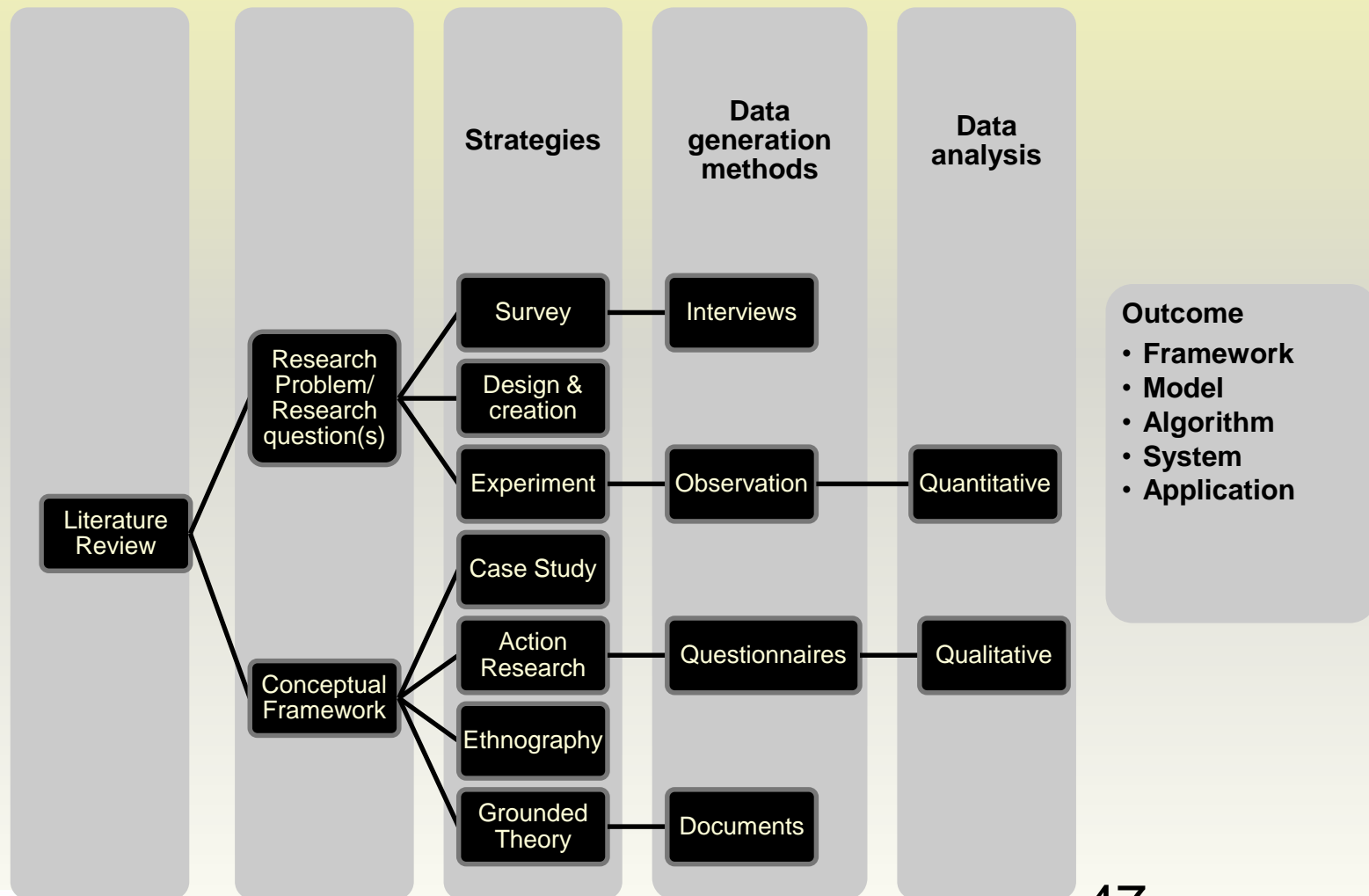
The processes of research

- not an “exact science”
- can be very messy
 - many important discoveries are made in very unscientific, even improbable ways.
- formal treatment of research
 - prepares you for a result when and if it appears.
 - Be ready to observe the unexpected and unwelcome

Activities in a Research



Research Process



Research

- Creation of new knowledge, using an appropriate process to the satisfaction of the users of the research

Everyday thinking	Good academic research
<ul style="list-style-type: none">• Poor data• Incomplete data• Hasty thinking	<ul style="list-style-type: none">• Sufficient data sources• Appropriate data sources• Accurately recorded• Properly analysed• No hidden assumption• Conclusion well-founded• Properly presented
As judged by the users of the research	

The Research Question

- A question that guides your research
- Characteristics
 - State the main concepts
 - Is neutral (debateable)
 - Clear and specific
- The question should
 - Define the research
 - Guide your inquiries
 - Frame your arguments
 - Be likely to produce your “contributions”

Thinking about the question

- What is the problem you are attempting to address?
- What is the unsolved problem that your research will attempt to resolve?
 - What?
 - Why?
 - Where?
 - When?
 - Who?
 - How?

Is the Question Reasonable?

- What is the context of the question?
- Is the question significant?
- What is everyone else doing?
- Is there a point of attack on the problem?
- Do I like the question?
 - Am I curious about it enough to pursue it?
- Can it be done in the length of time I am willing to spend on it?

Example Proto-Questions

- Is there an algorithm that can solve X?
 - Can something be done at all?
- How can this X be improved...?
 - Can something be made better?
- Why does X work?
 - Why does this give the right answer?
- What is the explanation for the phenomenon demonstrated by X?
 - What are the theoretical underpinnings of this
- Can we apply the technique of Y to X to get Z?
 - Can we nail a number of things together and get something new?

State a goal

- This is a description of the prize!
- Answers the “nature” of the answer to your research question
- does not actually answer the question.
- This statement will let you know when you are done.

Form a plan

- A research plan normally contains
 - Review of how others have addressed it.
 - Sometimes called a *literature review*.
 - Reasoning as to why the question is significant.
 - The methods you intend to apply to the problem.
 - Called the “approach”
 - The resources you will need.
 - The Timetable you intend to follow.
 - The Milestones you will reach.

This is often also a Grant Application

Formulate experiments and hypotheses

- Experiment
 - Set of actions to be performed and observations made
 - Hypothesis
 - A statement as to what you think will happen in the experiment
 - The lucky/informed/brilliant/horrible guess
 - Turns into your thesis statement
- Science is not always this clean

Activities to Follow

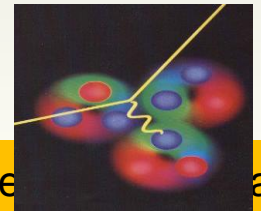
- What are your assumptions
- Collect, record and interpret data
 - Sometimes a “black art”
 - What data do I need?
 - What does it mean?
- Avoid the temptation to “avoid interpretation”
- Remember
 - Research doesn’t happen in straight lines
 - The chances of you being right are small for any given experiment/hypothesis pair.

The Thesis Statement

- States your position on a research question once you're working on the question
- This is what you “defend” in your defence
- Characteristics
 - Reference the research question,
 - Unambiguous indication of your view
- “your view” is developed from doing the research to answer the research question.

Basic Research

- Add to our basic knowledge about the world.
- Attempts to shed light on conceptualization about a particular phenomenon
- Basic research results tend to be generally true but not immediately (if ever) applicable to real world problems.
- Eg.:
 - Physicist might be interested in the basic elements that make up matter
 - Psychologist might want to shed light on human cognition



Applied Research

- Research have more immediate relevance to existing practice.
- Relates to practical problems
- Preferred by industry and government as it is likely to have consequences that can be measured in the shorter term



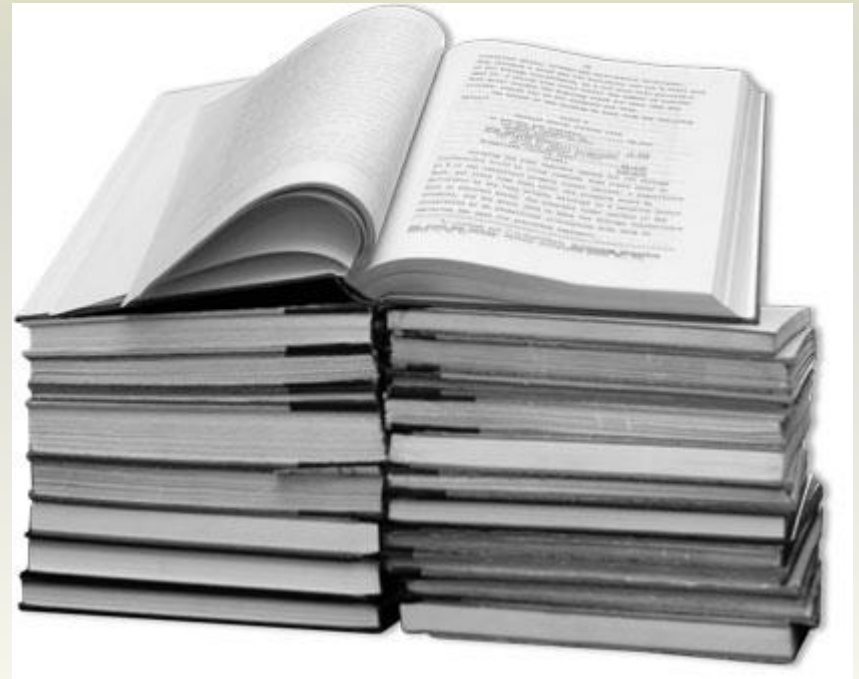
Basic vs. Applied Research

- The line between basic and applied research is often fine or missing completely.
- Basic research can often lead to changes in current practices if a connection is made between its result and how things are currently done.
- Applied research often inspires how a basic research problem might be attacked. In either case, both types of problems are valid

Unsuitable problem

- Research is not simply learning about something
- Research is not the simple comparison of data sets
- Correlating data sets is not research
- Research problems do not simply result in a “yes” or a “no” answer

Computer Science Research



What is Computer Science?

- The systematic study of computing systems and computation. The body of knowledge resulting from this discipline contains theories for understanding
 - computing systems and methods;
 - design methodology,
 - algorithms, and tools;
 - methods for the testing of concepts;
 - methods of analysis and verification; and
 - knowledge representation and implementation.

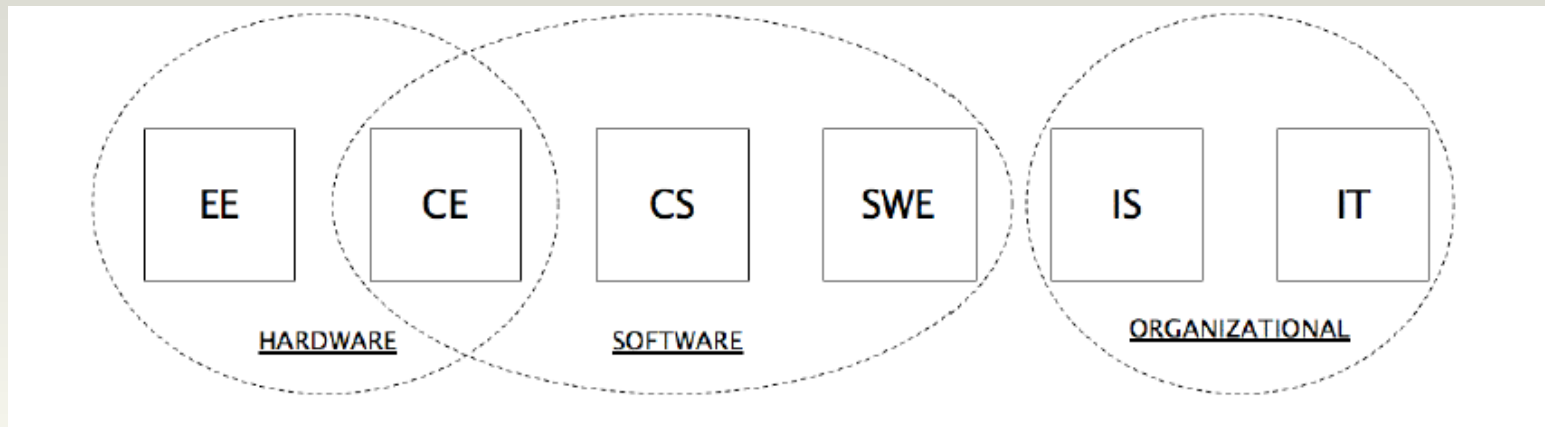
This is broad enough to offend
no one!

Computer Science

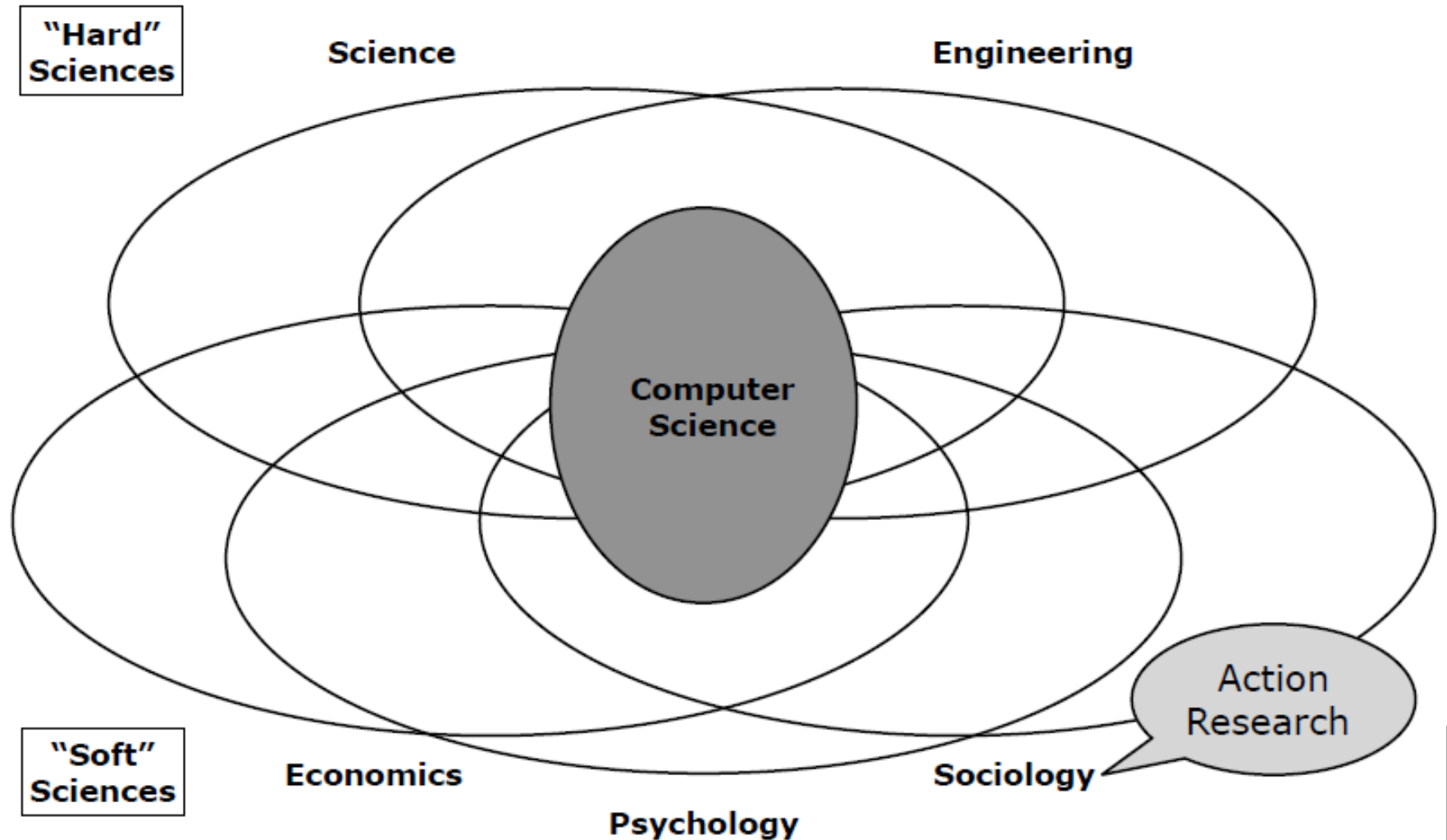
- Computer Science is about problem solving.
- Therefore the qualities of a good computer scientist include:
 - Passion for finding elegant solutions
 - Ability to use mathematical analysis and logical rigor to evaluate solutions
 - Creativity in modeling complex problems through the use of abstractions
 - Attention to details and hidden assumptions
 - Ability to recognise variants of the same problems in different settings
 - Able to retarget known efficient solutions to problems in new settings

Computing Discipline as defined by ACM & IEEE

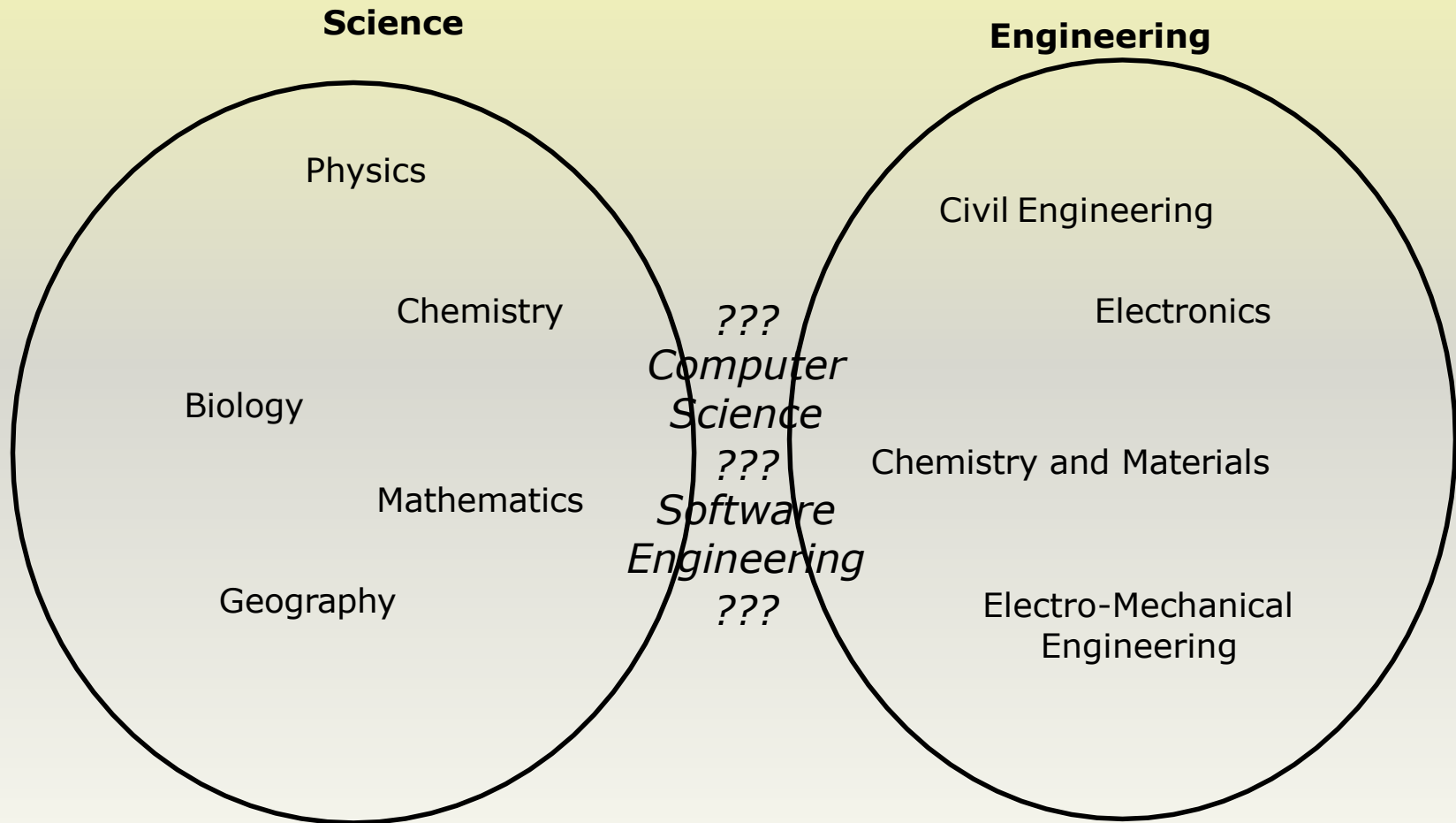
- EE – Electrical Engineering
- CE – Computer Engineering
- CS – Computer Science
- SWE – SoftWare Engineering
- IS – Information System
- IT – Information Technology



Interdisciplinary Nature



Science vs. Engineering



Mathematical Origins

Turing Machines

- Halting problem

Algorithmic Complexity

- $P = ? NP$

Compilers

- Chomsky hierarchy

Databases

- Relational model

(inductive) Reasoning

- logical argumentation
+ formal models, theorem proving, ...
- + axioms & lemma's
- + foo, bar type of examples
- “deep” and generic universal knowledge

Gödel theorem: consistency of the system is not provable in the system.

⇒ A complete and consistent set of axioms for all of mathematics is impossible

Engineering Origins

Computer Engineering

- Moore's law: "the number of transistors on a chip will double about every two years"
- + Self-fulfilling prophecy
- Hardware technology
- + RISC vs. CISC
- + MPSoC
- Compiler optimization
- + peephole optimization
- + branch prediction

Empirical Approach

- Tom De Marco: "you cannot control what you cannot measure"
- + quantify
- + mathematical model
- Pareto principle
- + 80 % - 20 % rule
(80% of the effects come from 20% of the causes)

As good as your next observation.

Premise: The sun has risen in the east every morning up until now.

Conclusion: The sun will also rise in the east tomorrow. ... Or Not ?

Influence of Society



Lives are at stake (e.g., automatic pilot, nuclear power plants)

Huge amounts of money are at stake (e.g., Ariane V crash, Denver Airport Baggage)



Software became Ubiquitous
... its not a hobby anymore



Corporate success or failure is at stake (e.g., telephone billing, VTM launching 2nd channel)

What is Computer Science Research?

- A human activity based on the intellectual investigation of aspects of the world related to the discipline of Computer Science for the purpose of discovering new knowledge, interpreting existing knowledge or revising erroneous or incomplete knowledge.



Is Computer Science a Science?

- Yes but we sometimes go astray
- Sample of 400 computer science papers published before 1995¹
 - 50% of those proposing models or hypotheses did not test them.
 - In other fields of science the fraction of papers with untested hypotheses was about 10%.
- Caution:
 - Our failure to test more allowed many unsound ideas to be tried in practice and lowered the credibility of our field as a science.

1 . Tichy, W. Should computer scientists experiment more. IEEE Computer(May 1998), 32-40.



Categories of Research in CS

- Application-Based Research
 - How knowledge areas of CS can contribute to other fields eg Bioinformatics, Healthcare, tsunami detection system, earthquake prediction system
- Theory-Based Research
 - How knowledge of CS can be enhanced, improved, formulated eg Fuzzy Set Theory, Pattern recognition.
- Industry-based Research
 - Practical usage eg CAD, QC Dept, Human resource dept.

Types of Research in Social Science

- Basic research – aimed at generating fundamental knowledge and theoretical understanding about basic human and other natural processes
- Applied research – focuses on answering practical questions to provide relatively immediate solutions
- Action research – on solving practitioners' local problems



More
Specific

Research Project Life Cycle

- Typical steps of doing research project are as follows:
 - Choose research question, problem or tradeoff
 - Determine current state of knowledge
 - Apply appropriate methods to produce research results.
 - Write up research results. Research is not complete until it is written up

Sources of research ideas

- Suggestions from people
- Past research students' work
- Recent conference & journal paper
(www.scholar.google.com)
- Call for papers
- Current issues
- Clients needs
- To support or refute certain statements
 - e.g: - Green computing is the future
 - Social networking is the future communication
 - Baby dumping is the result of new year events

Examples of Activities to Produce Research Results

- Writing programs or developing systems
- Developing architectures
- Measuring properties of units (i.e. technology) eg. Security vulnerabilities in WSN
- Finding and proving theorems
- Analyzing and consolidating previous research
- Interviewing experts and customers
- Performing psychological experiments, surveys and observations
- Building hardware
- Analyzing literature
- Importing techniques and results from other fields
- Measuring and predicting constraints or impacts on future units such as wireless technology, government, regulation, user expectations and requirements

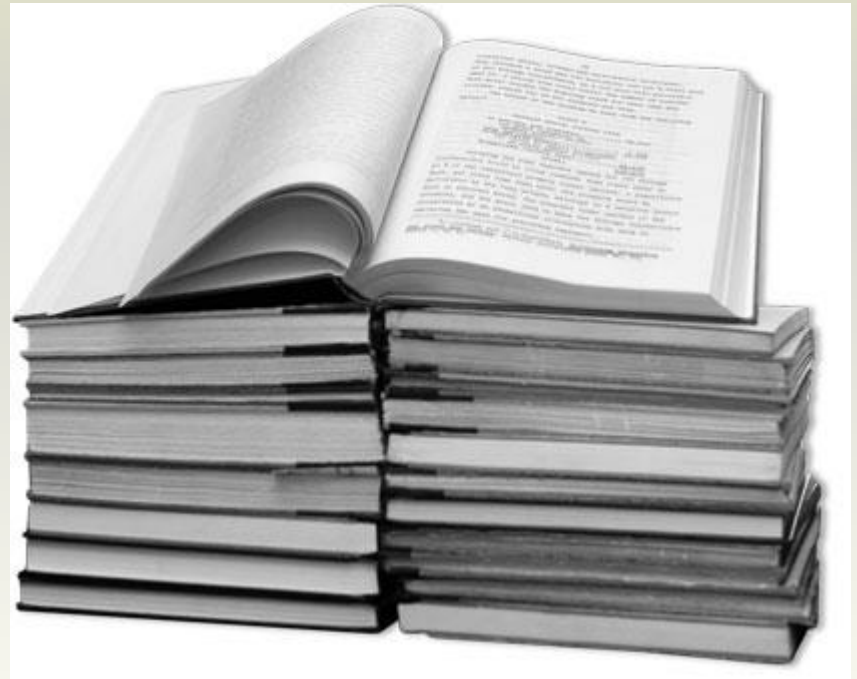
The outcome of research

- A new or improved product
- A new theory
- A re-interpretation of an existing theory
- New or improved research tool or technique
- A new or improved model or perspective
- An in-depth study of a particular situation
- An exploration of a topic, area or field
- A critical analysis
- Unanticipated outcomes

Research Results in Computing

- Research in computing can result in the following artifacts:
 - A definition of a problem, process, task or phenomenon (eg. Outcome of LR)
 - A unit (algorithm/approach/method/scheme) for solving a problem or performing a task
 - Identification of factors influencing the cost, effectiveness or applicability of a unit (perhaps with some idea of the relative importance of the factors)
 - Development of a model
 - A finished unit that can be distributed to users
 - Measurement of some properties of a unit: run time, chip area, representation requirements, reliability, usability, etc
 - Identification of problems and shortcomings in a unit (fr LR/initial experiment)
 - A demonstration that one unit is better than another
 - A definition and demonstration of a tradeoff
 - A generative (explanatory) theory for some set of units

Being a Researcher



Researcher Development Framework



Who is a Researcher?

- Matured
- Ability to focus and concentrate
- Disciplined
- Independent
- Hardworking
- Innovative & Creative
- Critical Thinking
- Available (time)

Research Skills

- To prepare effective proposal
- To generate results
- To communicate results : presentation & publication

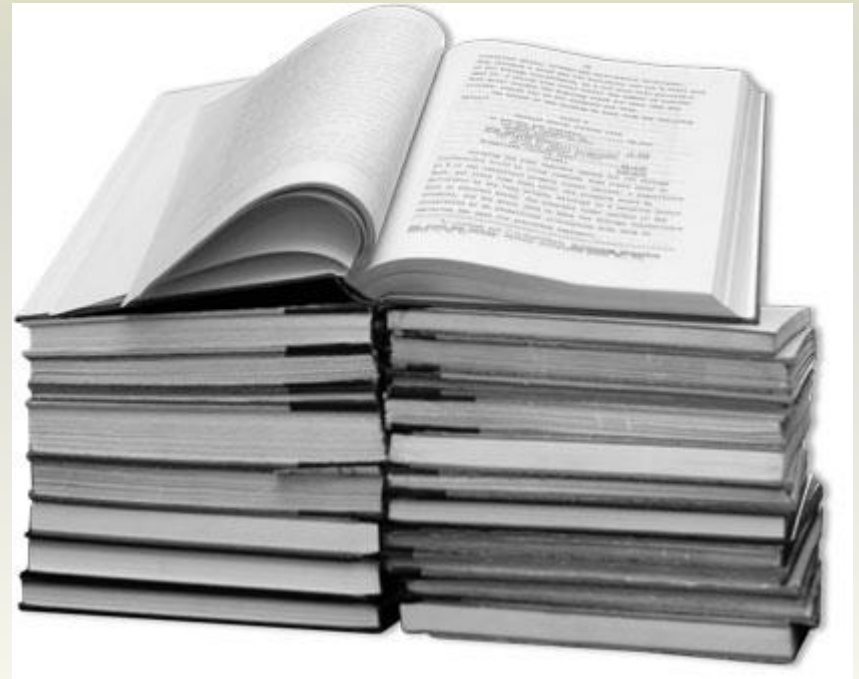
Think Like A Researcher

- An investigation (an inquiry) to find something out.
- Controlled inquiry concerning certain events.
- Problem solving.
- Application of the scientific approach to study a problem
- Systematic , controlled, empirical and critical investigation guided by theory and hypothesis.

Think Like A Researcher (cont.)

- Encounter problems
- State problems
- Propose hypotheses
- Deduce outcomes
- Formulate rival hypotheses
- Devise and conduct empirical tests
- Draw conclusions

PhD Research



EXPECTATION OF A PHD RESEARCH

Substantial body of
original and
significant work

Originality

- Nine times out of ten, is not about *invention* but about *combination*.
- Potential for originality arise by linking 'ideas' ('ways of marshalling the facts to produce arguments, inferences, hypotheses and conclusions') and 'facts' ('verifiable data'), and whether they are 'old' or 'new', as follows:
 - New facts + new ideas.
 - New facts + old ideas.
 - Old facts + new ideas.

Facts vs. Ideas

- Research is more than mere experiments -- it means interpretation and deep understanding.
- For Computer Scientists
 - New abstractions, new approaches, new algorithms, new principles, or new mechanisms.
 - Discovery of new techniques that aid in building or using computational mechanisms.
 - Uncovering principles that underlie digital computation and communication.

Concept of Originality (cont..)

- Setting down a major piece of new information in writing for the first time
- Continuing a previously **original piece** of work
- Carrying out **empirical work that has not been done** before
- Using **already known material** but with a **new interpretation**
- Trying out in this country that has previously only been done in other countries

Concept of Originality (...continue)

- Taking a particular technique and applying it in a new area
- Bringing a new evidence to bear on an old issue
- Being cross-disciplinary (integration) and using different methodologies
- Looking at areas that people in the discipline have not looked at before
- Adding to knowledge in a way that has not previously been done before

Contributions

- Your research should produce something new—These are your contributions
- Your contributions flow from the answers to your research question and are (often) encapsulated in your thesis statement
- Contributions are put in the context of existing scientific literature (current practice)

Contribution

- Contributions made to the field is identified
 - Gap filled
 - Inadequacies addressed
 - Extending the boundary of knowledge
- Results of research could be applied for practice/ in the wider field
- Implications for future research indicated
 - New territory
 - Unfinished business
 - Extension of Work

Contribution of Research

- **thesis**
 - original statement of an idea. However, very few research contributions can claim total originality. Most borrow ideas from previous work, even if that research has been conducted in another discipline.
- **antithesis**
 - argument to challenge a previous thesis. Typically, this argument may draw upon new sources of evidence and is typically of progress within a field.
- **synthesis**
 - form a new argument from existing sources. Typically, a synthesis might resolve the apparent contradiction between a thesis and an antithesis.

Example: debate over prototyping

- some authors have argued that prototypes provide a useful means of generating and evaluating new designs early in the development process (thesis), (Fuchs, 1992).
- Others have presented evidence against this hypothesis by suggesting that clients often choose features of the prototyping environment without considering possible alternatives (antithesis) (Hayes and Jones, 1989).
- A third group of researchers have, therefore, developed techniques that are intended to reduce bias towards features of prototyping environments (synthesis) (Gravell and Henderson, 1996).
- Research in a field progresses through the application of methods to prove, refute and reassess arguments in this manner.

SIGNIFICANT CONTRIBUTION

- A PhD is a substantial body of **original, significant** work
- Contain 2-3 key ideas you can articulate at the drop of a hat (think “elevator speech” - NABC).
 - What is the **NEED**?
 - What is your **APPROACH** to address the need?
 - What is the **BENEFIT** of your approach over cost?
 - In what ways are your approach better than the **COMPETITION**?

Significance

- Graduate students do not have the perspective to know what qualifies as “significant”; this determination falls within the realm of the supervisor.
- Research is not necessarily of a doctoral standard just because it is a lot of work, is systematic, establishes facts or collects information
- Doctoral research are expected to have a sense of being worthwhile, i.e. be non-trivial

Research Significance

- Research is more than mere understanding
 - Requires interpretation
 - Deep understanding
- If the results of the research can be predicted, then the research is not significant
- Significance (NABC)
 - What is a **Need**
 - What is your **Approach** to address the need?
 - What is the **Benefit** of your approach over cost?
 - In what ways are your research better than the **Competitors**?

Publishable

- A PhD work is expected to show *potential for publication*
- Having some of your work in press or published provides examiners with *prima facie evidence* that your work satisfies the requirement to be of publishable quality
- Not all the doctoral research reported in the thesis must be worthy of publication – it is *sufficient for some of the research* to attain this standard.
- Some universities specify that the quantity and quality of the thesis should be approximately equivalent to any number from one to four journal publications

PhD - Significant, Scientific, Standard & Specific

- Ensure that the research makes **significant** contribution
- Ensure that it is a **scientific** research, not just engineering
- Make sure you achieve the **standard** required of a PhD research
- Make your objectives **specific** and SMART

Four main methods to understand the expected standard of your PhD research:

- Identify the regulations and expectations as set out in formal university documents.
- Discuss such issues with your supervisor, other academics and other PhD students.
- Read other PhD theses in your research area
- Investigate and be aware of the criteria that PhD examiners use to assess doctoral research

What's a Great Ph.D. Thesis?

- **One that kicks the door open for another 3-4 future dissertations**
 - Means that you started an area of work or a line of thought that opens many more lines of thought
- **High-impact, i.e., “*Look, I*”**
 - Have left my mark behind in my field
 - Fundamentally changed the way that something is done today
 - Introduced a new concept that can be “mined” by others in the future
 - Solved a problem that has plagued the field for years
 - Eliminated a fundamental assumption that has been made in the field
 - Provided strong empirical evidence that the field has been lacking
 - Will continue to influence the field and be cited by others

Motivation for Doing PhD

- Requirement for a scholarly career.
 - preparation that enhances academic career potential.
- Requirement for career as a practitioner.
 - credentials to practice or economic incentives
- Evidence of intellectual competence.
 - evidence of intellectual ability
- Evidence of scholarly achievement.
 - evidence of research work and related scholarly activities

Problems in PhD

- High percentage of non-completion
- Long process towards completion
- Candidates regard PhD period as lonely and stressful episode, at high personal cost, and without 'mentor' to discuss problems;
- Meetings have inadequate frequency and depth, often no regular performance and progress interviews;
- Completed PhDs have low scientific and social impact, wasteful research time and money.

Sources of Problems

- Poor research design, no focus, no adequate research question;
- Lack of realistic expectations ('targeting the sky');
- Inadequate research background; lack of training in methodological and writing skills (inadequate Bachelors and Masters training);
- Problematic research facilities (time, office, computer, assistance, money, flexibility in rules, under-funding of essential tasks);
- Many competing tasks (teaching, consultancies, family life);
- Bad planning, bad phasing, bad time management;
- Major problems with writing academic English;
- Negligent or inadequate supervision; often unclear, strained relationship;
- Inadequate networking: not aware of others working in the same field of studies, no contact with peers, parochial local research cultures;
- Breakdown of motivation, psychological stress due to isolation, feelings of uselessness;
- Lack of possibilities to participate in a vibrant research culture.

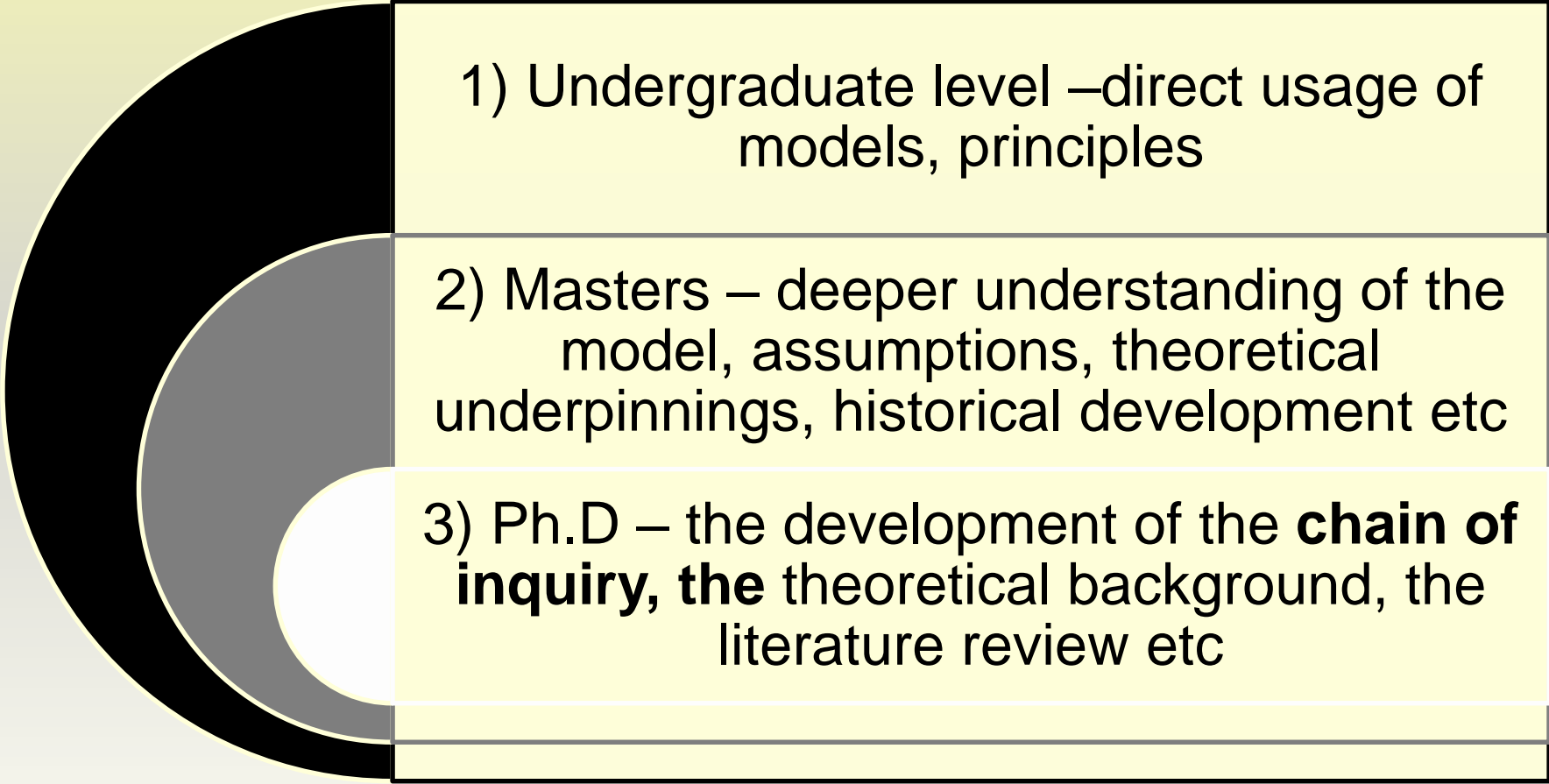
The SMART Acronym

- **S** - specific, significant, stretching
- **M** - measurable, meaningful, motivational
- **A** - agreed upon, attainable, achievable, acceptable, action-oriented
- **R** - realistic, relevant, reasonable, rewarding, results-oriented
- **T** - time-based, timely, tangible, trackable

To be SMART in your PhD Studies

- SMART in setting your **objectives**
- SMART in performing your **research**
- SMART in **managing** your PhD project
- SMART in writing up and defending your **thesis**

Differences between undergraduate project/research vs Masters and Ph.D thesis (research)



1) Undergraduate level –direct usage of models, principles

2) Masters – deeper understanding of the model, assumptions, theoretical underpinnings, historical development etc

3) Ph.D – the development of the **chain of inquiry**, the theoretical background, the literature review etc

Purpose of Graduate Education

- The purpose of graduate education is
 - To extend the frontiers of knowledge
 - Thus, the depth and breadth of study, originality and creativity is in



Comparison Between Masters and PhD Research

Masters:

- To solve a problem using the methodology that you have learned
- 1 paper of good journal



PhD

- Using the methodology that you have learned and experience of solving problem, to **produce something new**
- At least 2 papers of good journals
- At least 2 chapters of results in thesis (better 3 chapters)

Comparison of Different Academic Degrees

Level	Description	Criteria
First degree & master project	Project report	A well structured convincing account of a study, the resolution of a problem, or the outcome of an experiment
Master by Dissertation	Dissertation	<ol style="list-style-type: none"> 1. An ordered, critical and reasoned exposition of knowledge gained through the student's effort 2. Evidence of awareness of the literature
Master by Research	Thesis	<ol style="list-style-type: none"> 1. Evidence of original investigation or testing of ideas 2. Competence in independent work or experimentation 3. An understanding of appropriate techniques 4. Ability to make critical use of published work and source materials 5. Appreciation of the relationship of the special theme to the wider field of knowledge 6. Worthy, in part of publication
Doctoral degree	Thesis	<ol style="list-style-type: none"> 1. 1-6 as for master by research 2. Originality as shown by the topic researched or methodology employed 3. Distinct contribution to knowledge

Research Paradigm

Dr Fatin Aliah Phang



THANK YOU