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Be an Independent, Effective and Productive Researcher: Some Advice to Postgraduate Students

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Outlines

- My experience and lessons learned as a research student
- What is research and why do we pursue research?
- Key elements of research
- Good project requires good start & good design
- Thorough, effective, efficient and productive research conduction and execution
- Excellent technical writing and quality publishing
- Concluding remarks
- Acknowledgement

1. My Experience and Lessons as a Research Student

Experience and Lessons

- I did my final year research project for 0.5 year in BE, 2 years in ME and 3.5 years for PhD;
- I learnt so many lessons and I could have done much better (only if I have a second chance);
- Key question: "how to be an independent, effective and productive researcher?"
- This has made me to share the following with you…

Some Symptoms I Had (1)

- Experiences such as "all the original research have been done by others, there is nothing left for me to do";
- Often treating the results/methods reported in published journal papers being all correct, or as "words from bible" and "untouchable";
- Reading a paper multiple times but remembering little for proactive thinking;

Some Symptoms I Had (2)

- Being a good instruction taker but with little proactive thinking (or even not aware of that);
- Starting with great enthusiasms but losing motivations quickly after multiple times of goalless attempts;
- Ineffective writing, taking constant major revisions in preparing a draft manuscript.

Symptoms in Keywords

- Dependent;
- Ineffective;
- Inefficient;
- non-productive.

These reflected key hurdles which I had to climb over to transform myself into an independent researcher.

2. What is Research and Why Do We Do Research

What is Research?

- Either (or a combination) of three objectives:
  - Discover or create new knowledge;
  - Develop new technologies/processes;
  - Develop new products.

- Types of research (and development):
  - Basic (or fundamental) research;
  - Applied research;
  - Technological development.

Research Work (1)

- Objectives:
  - Get ourselves trained with new/advanced skills;
  - Learn and discover new/advanced knowledge;
  - Challenge ourselves;
  - Transform ourselves into independent thinkers;
  - Receive Bachelor, Masters or PhD degree certificates

- Within limited time:
  - Undergraduate Research Project: 0.5 – 1 year
  - Masters: 2 – 3 years
  - PhD: 3 – 5 years

Research Work (2)

- An expensive investment:
  - We are investing our time;
  - Research costs money;
  - Hard work is essential and required.

- Key questions must be asked before we start:
  - Are we really interested in postgraduate study?
  - Are we sincerely committed in postgraduate study?
  - Are we likely going to enjoy what we will do?

Postgraduate Study (3)

- For any investment, the return on Investment (ROI) must be maximised;

- Indicators for ROI:
  - High-quality publications archived in the literature;
  - New inventions in the form of patents;
  - Improvements in practical applications;
  - Good academic transcripts;
  - Smooth bridging between study and career path:
    - Good jobs (high pay, excellent self-satisfaction)
    - New opportunities

3. Key Elements of Research

Three Key Elements

- An innovative and workable project that is achievable within a given timeframe;
- An effective and efficient team;
- Availabilities of essential research facilities and analytical instruments.

I will spend a bit more time on the first 2 points because the 3rd dot-point is mostly rest in the hands of your supervisor.

An Innovative and Workable Project that is Achievable within a Given Timeframe

- An innovative project will deliver something new;
- Project objectives are clear:
  - We know ***what*** to do;
- Research methodologies are clear and workable:
  - We know ***how*** to do;
- Objectives are achievable within the time frame:
  - We know ***when*** to do what, how to do, with certainty;

An Effective and Efficient Team

- Research team members:
  - You as research student;
  - One or more supervisor(s);
  - Senior researchers in the team (*sometimes);*
  - Lab technicians (*sometimes)*.

  Supervisor-student relationship is discussed in the following slides.

- Effective and efficient research conduction:
  - Working hard is essential;
  - Working smart is important and critical.

Supervisor *vs* Research Student

Supervisor

Captain of the ship:

- ✓ Layout the research direction;
- ✓ Devise key research methodologies;
- ✓ Provide essential guidance;
- ✓ Ensure the students have not been diverted too far;
- ✓ Suggest alternative options;
- ✓ Foster intellectual stimulation;
- ✓ Offer training of technical writing;
- ✓ Allow freedom for independent thinking.

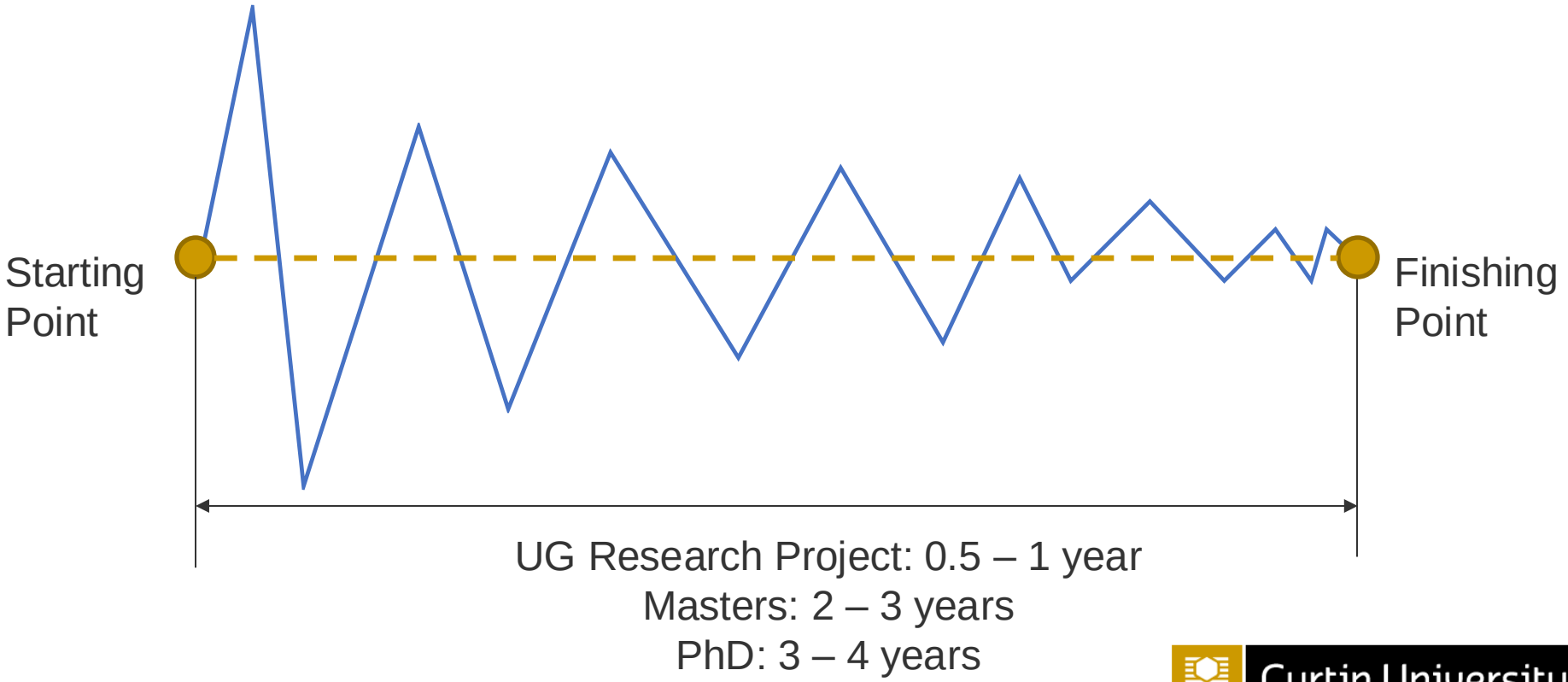
Research Student

Under guidance of supervisor(s):

- ✓ Understand research objectives;
- ✓ Identify research gaps via literature review;
- ✓ Design at least part of the research program with guidance;
- ✓ Master research techniques;
- ✓ Execute the research program accurately and efficiently;
- ✓ Process the results timely;
- ✓ Draft research publications.

Supervisor(s) are Catalysts of Students' Study

- Catalysts can promote, inhibit or neutralise (do nothing) reactions;
- Catalysts promoting reactions are NOT always good, in some cases students may be shrunk to pairs of hands.



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Supervisor-Student Relationship

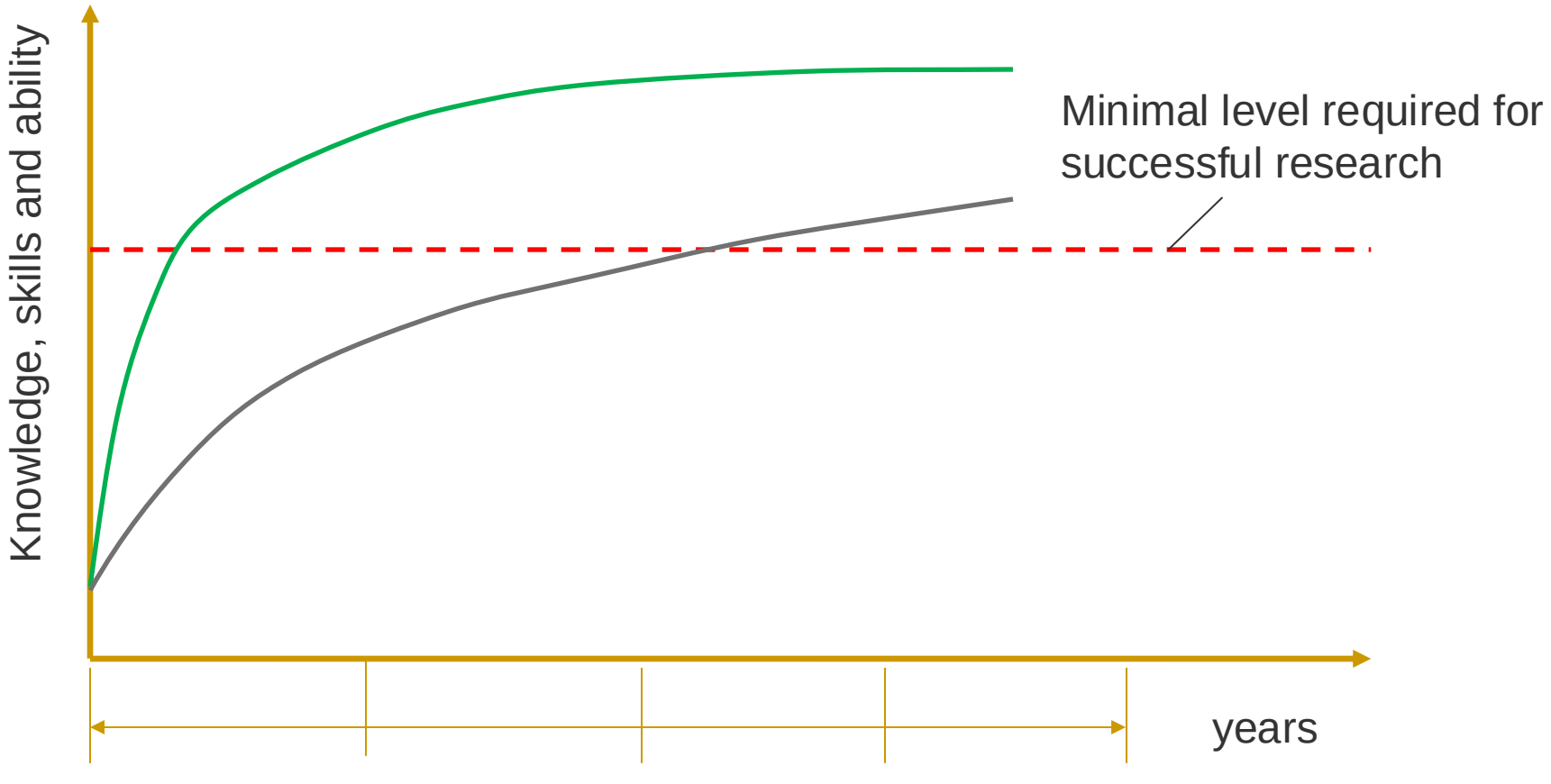
- Educator vs Student;
- Mentor vs Junior researcher;
- Trainer vs Trainee;
- Friend vs Friend.

1. In front of science, supervisor(s) and students are equal. Seniority is NOT and should NEVER be a factor.
2. Supervisor(s) and students are in the same boat, sharing the same glories, fame/infame and responsibilities.

4. Good Project Requires Good Start and Good Design

Initial Learning Curves

- Initial learning curve plays an important and critical role



UG Research Project: 0.5 – 1 year
Masters: 2 – 3 years
PhD: 3 – 4 years

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Literature Review is Essential

- Literature review is NOT just reading a lot of papers;
- Via literature review, students must know:
  - What have been done so far?
  - What can be done?
  - What were methods used in the previous studies?
  - Can we do those in better ways?
  - Can we propose any new and better ideas or develop better methods?
- Literature review is an entropy reduction process, requiring the input of significant work!

Two Key Objectives of Literature Review (1) Knowledge Synthesis

- The first most important objective of literature review is “Knowledge Synthesis”:
  - Categorise knowledge into well-organised fashion;
  - Synthesize new knowledge and understanding;
  - List key research questions to be answered;

Two Key Objectives of Literature Review (2) Identification of Research Gaps

- The second most important objectives of literature review is "Identification of research gaps":
  - Clearly understand the knowledge gaps and existing research challenges in the related fields;
  - Propose new research ideas and perspectives;
  - Develop new research methodology;

Without a good literature review, we won't be able to design and conduct a good research program.

Some Advice (1)

- Bravely challenge the results and methods in published journal/conference/symposium papers;
- Try to foster synergies among published/reported methods used in different papers;
- Always ask questions;
- Give a thorough thinking before action, don’t rush;

Some Advice (2)

- Avoid getting drown in information ocean, always reminding ourselves where the lighthouse is;
- Try to tackle the problems from the bottom-line;
- Take a good approach in reading (thinner – thicker – thinner);
- Always take notes and do periodic summarisation timely.

5. Thorough, Effective, Efficient and Productive Research Conduction and Execution

Essential Requirements

- Know what, how and when
- Plan - “If you fail to plan, you plan to fail”
- Organise and prioritise
- Quickly summarise
- Stick to the timeline (deadlines)

Principles (1)

- Conduct work that is systematic, complete and self-contained;

- Realise innovative design of sample matrix and facilities
  - Make it simple but not simpler;
  - Ideally adjust only one parameter a time;
  - Design innovative experimental/analytical systems;
  - Devise new modelling approach.

- Employ advanced methodology to
  - Obtain new data that nobody has reported before;
  - Probe the same phenomena from different angles, with new depth;
  - Open completely new horizons (if we are lucky).

Principles (2)

- Calibrate any physical/chemical quantity
  - Temperature, pressure, mass, flow rate etc
  - Concentrations, pH etc
- Calibrate any instrument
  - Sandwich method
  - Double checking
- Ensure the reproducibility of all experiments
  - Ensure correctness and accuracy
  - Have a good idea on error bars

Principles (3)

- Ensure occupational health and safety
  - OHS is No. 1 priority in our operations;
  - There are strict Commonwealth/State laws and regulations governing OHS;
  - Sticking to the OHS rules is of the best interests to ourselves, our families, the department and the university at large;
  - The institutions have duties of care for OHS;
  - A set of essential OHS documents must be in place before anyone can enter the lab for conducting experiments/analyses;
    - HAZOP analysis
    - Lab inductions
  - Non-compliance can lead to severe consequences.

Principles (4)

- Pay serious attentions to unexpected results
  - Additional experiments should be done, to rule out or to confirm;
  - Either of the following two consequences:
    - We have done something silly;
    - There is something new.
  - Personal emotion should NOT be a factor.

Serendipity

accounts for almost 50% of science discoveries

6. Excellent Technical Writing and Quality Publishing

Purposes of Publishing Papers

- Crystallising the results and thinking;
- Advancing science or technological development;
- Contributing to the literature, sharing with other researchers.

Irreversible: once published, a paper is in the public domain forever; it will be there longer than any of us will.

- To be famous or infamous? Via publication, we tell other fellow researchers in the field either of the 3 consequences:
  - we have done something useful;
  - we have done nothing;
  - we have done something wrong to confuse others.

Signs Showing We are Not Ready (1)

- Sitting in front of computer, squeezing our brains for the last word squeezable;
- Constant revisions of the same sentences/paragraphs;
- Taking weeks even months for writing a draft;
- Sighing for being the most unlucky bunch in the world, leaning to give up research;

Signs Showing We are Not Ready (2)

- Being unclear on the originality of our work;
- Having no clear idea on the theme of the paper;
- Reporting only piles of data, without in-depth discussion and interpretation;
- Often with conclusions like “the results reported in this study agree with…. in previous studies”.

Excellent Technical Writing (1) - Outlines

- Having a clear understanding on new contributions of the paper, i.e. originality, before starting writing;
- Having all the figures and tables in hand, with clear understanding on the key points to be talked about from each figure/table;
- Being crystally-clear on the major conclusions to be drawn from the paper;
- Articulating all of above into a clear logic theme before start to write the paper:
    - Constructing the logical flow of the paper;
    - Putting those into dot-point forms (max 3 pages).

Excellent Technical Writing (2) - Introduction

- The “Introduction” section is one of the most difficult sections to be written;
- The “Introduction” must provide the following:
  - A concise summary of the current status in the related subject;
  - Successful identification of some key research gaps;
  - Emphasis on the key research gaps to be filled by the current study;
  - Convincing justification why the current paper is worthy for publication.
- The “Introduction” section must be strategically written to:
  - Ensure all key and relevant works have been summarised;
  - Key and classic references must be properly cited;
  - Clearly spell out the originality of the work;
  - Avoid exaggeration.

Excellent Technical Writing (3) - Methods

- For existing methods: provide brief descriptions using concise writing with citations if possible;
- For new methods: all details on the procedure should be provided;
- Overall, the principle is to provide sufficient details (in the paper and also references) so that others can reproduce our work if needed;
- If insufficient space, some details can be relocated to Supporting Information (ACS) or Supplementary Material (Elsevier).

Excellent Technical Writing (4) - Results and Discussion

- Writing needs to be on the spot and focused on the new findings of this study;
- Error information must be presented to give statistic confidence in the results;
- Figures and tables need to be presented in a clear, concise and readable manner;
- In-depth analysis and discussion of our data must be done, leading to:
  - Discovery of new knowledge;
  - Deepened understanding in the field;
  - Development of new methods for analysis, etc;

Excellent Technical Writing (4) - Results and Discussion

- The logical structure should flow fluently, guiding the readers/reviewers through the whole paper from start to end smoothly;

- Any statements made in the paper must be accurate and supported by:
  - Our own data reported in the paper; and/or
  - Data/results reported in public literature, with proper citation/referencing.

- Speculations must be minimised or even eliminated.

Excellent Technical Writing (5) - Conclusions vs Abstract

- Conclusions are NOT abstract; Abstract is NOT repetition of Conclusions;
- Conclusions include key conclusions drawn from the study;
- Abstract includes concise background, experimental conditions, methods used and summarisation of conclusions;
- Abstract should include quantitative results.

Excellent Technical Writing (6) - Citations

- Proper citations are critical to maintaining the integrity of the open literature:
  - Only cite relevant papers;
  - Give credits to original papers;
  - Dodgy citations are offensive.
- Minimise self-citations unless those for originality and methods;
- Buddy citations are completely NOT ethical and readers can easily work those out.

Excellent Technical Writing (7) - English

- For technical writing, it is essential to read some good books on technical writing;
- One good example is ACS Style Guides;
- The other effective way is to read others' papers, especially those good papers, then follow their styles of writing;
- Avoid writing long sentences and always using short and concise sentences.

More to Remember in Writing

- Don’t rush to write but also don’t delay writing if we are ready;
- Ethical standards must be followed, considering using iThenticate scanning to avoid pitfalls;
- Technical writing has little to do with the language we speak; it is decisively determined by the way of logical thinking;
- It takes 10 or more good papers to establish our reputation but only 1 poor paper to ruin that.

7. Concluding Remarks

Advice in a Nutshell

- Be Creative
- Work hard (not work hardly)
- Work smart
- Use our time wisely
- Pursue good teamwork
- Write concisely
- Be honest
- Be ethical

Never give up easily. Nothing is easier

Finally…Please Keep in Our Mind

- Research may be a hobby but it is also a profession

- Upon graduation, we are trained to be
  - independent researchers (professionals);
  - independent thinkers;
  - technologists (NOT technicians);

- Receiving a given fish *vs* mastering the ability to fish;

- Research can be very enjoyable and rewarding.

Acknowledgement

- My supervisors (my own experience as a research student);
- My students (my own experience and implementation as a supervisor);
- My Postdocs (with whom I have been working very hard to pass over what I have learnt);
- My peers (mirrors).

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Contact Information

If you need more information, or are interested in

- pursuing PhD study
- obtaining scholarships
- visiting Curtin or anything else

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