

How to Prepare Qualified Exams (QE): A Practical Guide

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Writing and Defending Your PhD Thesis in the AI Era

In this document, I aim to provide you with comprehensive guidelines on crafting your PhD thesis—from preparing for your qualifying exam all the way to your thesis defense. Drawing on my experience supervising around twenty PhD students, I will distill the essential elements that have consistently contributed to successful doctoral journeys.

A PhD thesis is not merely an academic requirement; it is the culmination of years of intellectual exploration, perseverance, and self-discovery. It stands as the most tangible record of your scholarly growth—your ability to identify important research questions, devise innovative solutions, and contribute new knowledge to your field. Traditionally, a computing PhD thesis often consists of several peer-reviewed papers, ideally from top-tier conferences or journals, that collectively demonstrate a coherent research agenda.

However, beyond a compilation of publications, a PhD thesis should tell a story—one that connects your motivation, methodology, and findings into a unified narrative of scientific contribution. It should reflect not only *what* you have achieved but also *how* you think. The ultimate goal is for our students to emerge as independent researchers and recognized experts in their chosen domains. A successful PhD journey demonstrates this independence through a deep understanding of the field, the ability to formulate and pursue original ideas, and meaningful recognition from peers. Ideally, by the time you defend your thesis, you should stand among the top graduates in your specialty—someone capable of shaping the direction of future research rather than merely following existing trends.

To reach that point, it is essential to immerse yourself in your research community. Attend leading conferences, present your work, and engage in meaningful discussions with other researchers. These interactions not only sharpen your ideas but also help you see where your work fits within the broader landscape. Staying updated with the latest advances will enable you to identify gaps, position your contributions strategically, and ultimately make a stronger impact. The thesis-writing process itself should be iterative—draft, revise, seek feedback, and refine continuously. A good thesis is never written in isolation; it evolves through active dialogue with your advisor, peers, and the broader community.

Rethinking Doctoral Training in the Age of AI

In recent years, the academic landscape—especially in AI—has undergone a profound transformation. The number of publications and PhD students has expanded rapidly, leading to

a kind of *academic inflation*. On the surface, this seems like progress: more research outputs, faster dissemination, greater participation. Yet beneath this surge lies a deeper challenge—the erosion of independent thinking.

I have observed a growing number of students with several top-tier conference papers but still lacking the depth of thought expected of an independent researcher. There are multiple reasons for this. First, many AI papers today are becoming increasingly short-cycle and incremental, focusing on quick experimental tweaks rather than deep conceptual advances. Second, in some large research groups, publication has turned into a production pipeline: each member specializes narrowly—one focuses on data preparation, another on running experiments, another on writing or polishing the paper, sometimes even on drawing figures. While this division of labor increases efficiency and output, it often fragments intellectual ownership. The result is students who know *a part* of the process very well but lack a holistic understanding of how to conceive and drive a complete research project.

This trend challenges the traditional notion of using paper count as the main metric for evaluating a PhD's success. In the AI era, we must look beyond quantity. The goal of doctoral training should not be to produce paper factories but to cultivate independent thinkers—researchers who can identify meaningful problems, devise creative solutions, and see their work's broader implications.

Therefore, we need to redefine our expectations and metrics. A strong PhD student should aim for *impact*, not *inflation*. Impact can take many forms: a groundbreaking research paper, an open-source system widely used by the community, a benchmark dataset that shapes future studies, or even the establishment of a new subfield. The essence is originality, influence, and sustainability.

In this sense, the bar is actually higher than before. It is no longer enough to have several good papers; one must demonstrate the ability to lead ideas—to envision, execute, and communicate research that endures beyond short-term publication cycles.

In the chapters that follow, we will discuss each key milestone in your doctoral journey:

1. **Qualifying Examination (QE):** how to prepare and use it to build a strong foundation for your research direction. This is the content of this chapter.
2. **Thesis Proposal:** how to frame your research vision, articulate your contributions, and plan your remaining work strategically.
3. **Thesis Writing and Defense:** how to craft a coherent narrative that integrates your papers, positions your contributions in the literature, and presents a compelling case for your graduation.

These guidelines are particularly designed for students studying in systems similar to those in **Singapore and Hong Kong**, where the doctoral programs share many structural similarities. Regardless of location, the underlying principles remain the same: a PhD is not simply about fulfilling requirements—it is about maturing intellectually, developing independence, and learning how to make lasting contributions to your field.

If you approach this process with curiosity, discipline, and a sense of purpose, your PhD thesis will not just mark the end of a journey—it will mark the beginning of your life as a researcher capable of shaping the future of science.

Preparation for the Qualifying Exam (QE)

During the initial 1.5 years of your PhD journey, the **Qualifying Exam (QE)** marks one of the most pivotal milestones. It represents not merely an institutional requirement, but a personal checkpoint—a moment of reflection to assess whether you have truly begun to think like a researcher. Having supervised many students through this phase, I have come to view the QE as the first “rite of passage” in the transformation from a learner of knowledge to a creator of knowledge.

The QE serves three main purposes.

First, it evaluates your *comprehensive understanding of the literature* surrounding a particular research problem. This means going far beyond collecting and summarizing papers. You are expected to demonstrate your ability to **synthesize and critique** existing work—seeing not only what has been done, but what has been *missed*. The best QE reports I have read were those that tell a clear story: what the field has achieved, where it has plateaued, and what opportunities lie ahead. This ability to distill structure from complexity—to read between the lines of other people’s work—is a sign that you are beginning to see research as a living, evolving ecosystem rather than a pile of isolated papers.

Second, the QE evaluates your *preliminary research contributions*. By this stage, you should ideally have some concrete progress—perhaps a workshop paper, a submission under review, or early experimental results. The committee will assess your capacity to identify meaningful research questions, design appropriate methodologies, and interpret early findings. You are not expected to have solved everything yet, but you should be able to **argue convincingly why your chosen direction matters**, what makes it non-trivial, and how it could potentially advance the state of the art. This is your opportunity to showcase your maturity in thinking and your readiness to take ownership of your research trajectory.

Third, the QE is where you articulate your *thesis roadmap*. This involves presenting a structured plan for your remaining PhD years—your envisioned contributions, the methodologies you plan to employ, the evaluation criteria, and the expected impact. A well-defined roadmap signals both

intellectual clarity and strategic foresight. It helps the committee see that you are not wandering aimlessly, but building toward a coherent and ambitious research vision.

From my experience, I always advise students to use the QE as a **mirror**, to ask themselves:

“Have I found my research rhythm yet? Do I feel genuinely connected to my topic?”

This “feeling” is subtle but crucial. A PhD is a long journey—typically three to five years, sometimes more—and your topic will accompany you through many ups and downs. It must be something that sustains your curiosity even when things get hard, something that resonates with your sense of purpose. Without that spark of *feeling*, it is very difficult to persist through the inevitable frustrations and setbacks that every researcher encounters.

And indeed, the journey from QE to thesis is full of mixed emotions—what I often describe as “酸甜苦辣”, the full range of flavors in life. There will be moments of excitement when your experiments finally work, but also moments of deep frustration when papers get rejected multiple times, often with harsh or unreasonable reviews. You may even face situations that feel unfair or random—because, truthfully, the review process in modern academia is not always predictable. There will be days when you question your abilities, your topic, or even your decision to pursue a PhD at all. That is normal. Almost every successful researcher I know has gone through this phase. But I can assure you: **it is a “先苦后甘” process—bitterness first, sweetness later**. The key is to keep going, to treat every rejection as a revision of your understanding rather than a verdict on your worth.

The QE in the Age of AI

In the current AI era, the QE has taken on an even deeper significance. With AI tools capable of generating text, code, and even entire drafts of papers, the essence of research has shifted from *execution* to *vision*. Many students can now produce papers quickly—sometimes too quickly. Yet, I increasingly find that some of them, despite having several top-tier publications, still lack the sense of *ownership* and *independent thinking* that defines a true researcher.

This is why your QE should not just be about showing that you have read many papers or produced a few experiments. It should be about **showing your voice**—how you think, what excites you, and how your work connects to something larger than yourself. In the AI age, your passion and initiative matter more than ever. Topics should not simply be *assigned to you*; they should be *discovered by you*. Because only when you feel an inner drive—a genuine curiosity about the question—will you have the energy and persistence to go deep.

I often tell my students:

“Anyone can cook a dish from a recipe, but only a chef with passion can create a new cuisine.”

AI can now generate drafts of papers, much like following a recipe. But what truly distinguishes a human researcher is **the originality of taste**—the ability to sense which questions are worth asking, which assumptions are worth challenging, and which ideas could open new directions. Your QE is the moment when you begin developing that taste. It's the stage when you stop being a consumer of knowledge and start becoming a producer, a curator, a thinker.

Finding Your Passion and Research Identity

So, as you prepare for your QE, take time to reflect not only on *what you have done*, but *why you are doing it*. Ask yourself:

- Does this topic genuinely interest me?
- Am I learning to think independently, or just following instructions?
- Can I see a long-term research vision growing from this foundation?

If your answers are positive, that is a good sign that you have found your research identity. If not, it is still not too late—sometimes the QE itself helps you realize what direction truly fits you. Use it as an opportunity to refine your focus, clarify your motivation, and reset your compass if necessary.

Remember: your QE is not just an exam to pass; it is a **conversation with your future self**. It tests not only your knowledge but your commitment, resilience, and readiness to embark on the long, often lonely road of discovery. When you walk out of the QE room, ideally, you should feel not just relief, but also clarity—knowing that you are now on your own path, ready to build something that is uniquely yours.

Finding a Research Topic

Identifying a suitable research problem is often the most challenging part of a PhD. In the current era of information abundance—especially in fast-moving fields like artificial intelligence—this task can feel overwhelming. The pace of innovation is accelerating, and the boundaries between subfields blur quickly. What seems cutting-edge today may appear outdated in just a year or two.

While trending topics like ChatGPT, large language models, or AI agents receive immense attention, they can be **highly competitive and transient**. Working in such areas is like joining a marathon that started long before you arrived—the bar is high, and the pace is relentless. For a PhD, which typically spans several years, such volatility can pose significant risks. You may find yourself constantly chasing a moving target, struggling to make a distinctive contribution before the field moves on.

On the other hand, selecting a topic that is too **niche or “cold”** carries its own risks. If no one else cares about the problem, it might indicate that the question is not yet ripe for exploration or lacks broader relevance. Sustaining motivation and publishing impact in such areas can be difficult, as the community's attention and resources might be limited.

Therefore, **finding the balance** between novelty, relevance, and sustainability is key. The ideal research topic has enough intellectual depth to sustain multi-year investigation, enough openness to evolve with time, and enough importance to make you one of the few people in the world recognized for solving that particular problem. When you choose wisely, your PhD can become a launching pad—not only to complete your degree but to establish your identity as a researcher and future leader in your domain.

Passion, Patience, and the Process of Discovery

In the AI era, *choosing well may matter even more than working hard*. Effort without direction can lead to burnout and frustration. Thus, I often encourage my students to spend more time reflecting deeply on three fundamental questions:

1. What topics genuinely spark your curiosity and passion?
2. What kinds of problems align with your strengths—technical, analytical, or conceptual?
3. What do you hope to create or change in the world through your research?

The process of identifying your topic should not be rushed. It is a gradual, interactive process—one that evolves through reading, discussion, experimentation, and self-reflection. Don't be afraid to take a few months, or even longer, to think things through. In my experience, students who invest this time early on build much stronger and more coherent research programs later.

And even if you reach your **Qualifying Exam (QE)** without having found your “perfect” topic, that's fine. The QE itself can serve as an *exercise in discovery*. The key is to develop a sense of *what kind of problem excites you* and to cultivate your own internal compass for identifying good research directions. Once you have that intuition—a “feeling” for what makes a question meaningful—you will eventually find your topic.

Today, we are fortunate to have tools that can accelerate this discovery process. Large language models such as **ChatGPT** or **Gemini Advanced Research Mode** can help you map out the literature far more effectively than a manual Google Scholar search. These tools can summarize existing research, identify connections among papers, and even highlight emerging gaps or relationships across subfields. When used wisely, they act as your *research navigator*, helping you see the big picture before you dive into the details.

Hot Topics vs. Deep Topics

In my observation, research topics today generally fall into **two broad categories**.

The first category includes “**hot topics**”—highly active areas such as LLM safety, AI agent behavior, or alignment research. These fields are crowded but exciting. If you choose to work in

such an area, you must accept that the environment is extremely fast-paced. Every day, dozens of new papers appear on arXiv, and the half-life of an idea can be just a few weeks.

To succeed here, you need a strong foundation, quick execution skills, and the ability to generate and iterate on ideas rapidly. The typical rhythm might be one piece of work every two to three months—requiring focus, agility, and constant adaptation. You must also find a way to **differentiate yourself**—either by identifying a subproblem that others have overlooked or by bringing a unique perspective, such as a new methodology, system design, or interdisciplinary angle.

The second category involves **deeper or cross-domain topics**, which progress more slowly but often yield more sustained and meaningful impact. These include areas like **AI for psychology**, **AI for finance**, or **AI for sustainability**. In such interdisciplinary research, the challenges are different. You need to bridge communities, work with collaborators from other fields, and sometimes navigate ethical or procedural constraints such as IRB approvals. Progress may be slower, but the results often stand out because they combine depth, real-world significance, and long-term value.

For instance, in AI for social sciences or finance, algorithms alone are not enough—you must also understand human behavior, systems design, and real-world deployment. This inherently limits the pace of iteration, but it builds the kind of **research resilience** that distinguishes impactful scholars from short-lived trend followers.

Research with Purpose and Impact

When selecting your topic, also consider **the nature of your intended impact**. In my group, we often focus on *enabling infrastructure*—systems that improve **efficiency, scalability, and energy consumption**. I sometimes describe this as “*building the shovels and water pipes during the gold rush*,” instead of digging for gold ourselves. By empowering others—researchers, developers, and users—we ensure that our work remains relevant and valuable across many domains.

Similarly, when you plan your research direction, think about how your work might **create a feedback loop of impact**. Can your tools, datasets, or methods be open-sourced and used by others? Could your system evolve into a service or platform that benefits the community? These practical extensions often have a far greater and longer-lasting influence than the paper itself.

Ultimately, the most fulfilling PhD topics are those that blend **intellectual curiosity, real-world relevance, and personal passion**. They are not simply chosen—they are *earned* through reflection, exploration, and dialogue. Your research topic should feel like a calling—something that you can imagine working on for several years without losing your sense of wonder.

As you prepare for your QE and the journey ahead, remember that your topic will define not only your thesis but also your identity as a researcher. Choose it wisely. It is worth investing months of thought if that leads to years of meaningful work. A good research topic is not the one that

everyone is talking about—it is the one that you can talk about passionately, clearly, and originally.

In the AI era, where algorithms can write, summarize, and even propose ideas, *what truly sets you apart is your sense of direction and your taste in choosing problems*. Your creativity, judgment, and persistence remain irreplaceable.

So take your time. Discuss, explore, and think deeply. When you finally find the topic that resonates with both your curiosity and your ambition, you will feel it—like a quiet click. That is the moment your true PhD journey begins.

Literature Review

Once you have identified a potential research problem, the next critical step is to **immerse yourself in the literature**. This stage—often underestimated—is where a student begins to transform from a learner into an independent thinker. A well-conducted literature review is not simply a collection of summaries; it is a process of mapping a scientific landscape, identifying where knowledge stands, where the gaps lie, and where your contribution might fit.

When I was a PhD student around 2003–2004, I read over a hundred papers, out of which I studied roughly thirty to forty in depth. Even after nearly two decades, I still remember the details—the authors’ names, paper titles, the specific techniques they introduced, and even how their research directions evolved afterward. That experience was formative. It wasn’t just about reading; it was about *thinking with the authors*, understanding their logic, and questioning their assumptions. That kind of intellectual intimacy with the literature is what I hope every PhD student can develop.

Today, expectations are even higher. The body of knowledge has exploded. In the AI domain, thousands of new papers appear on arXiv every week, and the half-life of a “hot topic” can be as short as a few months. For current PhD students, reading perhaps 150 papers and studying at least 50 of them deeply may be the new normal. Yet, the goal remains the same: **quality over quantity**—to understand not just *what* was done but *why* and *how*.

Reading with Purpose and Depth

When engaging with a paper, strive for **deep comprehension**. Don’t just highlight the results—ask yourself critical questions:

- What problem is being solved, and why is it important?
- How does the methodology connect to the motivation?

- If I were tackling the same problem, would I choose a different approach?

Sometimes, I advise students to pause after reading a section and close their eyes for a few minutes. Try to reconstruct the logic chain in your mind: the hypothesis, the assumptions, the techniques, the evaluation. If you can retell the paper's story in your own words—and even imagine how you might improve it—you have truly understood it.

Equally important is to study the **author's research trajectory**. Don't treat each paper in isolation. If an author has a series of works on related topics, trace their intellectual journey. Perhaps their early paper introduced a simple static model, and later they explored a more dynamic or scalable version. Why did they pivot? What limitations or new insights prompted this change? Such longitudinal reading teaches you how research ideas evolve—how scholars refine questions, adapt methodologies, and sometimes reinvent their frameworks entirely.

Furthermore, situate each paper within its **community context**. Every research work is part of a larger conversation. Observe which conferences or journals the papers appear in, which research groups they come from, and how the supervisor's broader agenda shapes the work. This helps you understand strategic research alignment—how individual papers fit into multi-year projects or collaborations.

Also, pay attention to **networks and collaborations**. Many influential papers are not the product of solitary work but of teams connecting different expertise. Recognizing these networks gives you a sense of where ideas flow—between institutions, research labs, or even across continents. This awareness can later inform your own collaborations.

Finally, assess **innovation and relevance**. Ask:

- What new perspectives, algorithms, or systems does this paper introduce?
- Why does the community find it valuable?
- Does it open a new direction or merely optimize existing methods?

Understanding these nuances is crucial. It helps you distinguish between papers that make incremental improvements and those that shape the trajectory of a field.

The Challenge of Literature Review in the AI Era

However, in the current AI era, the challenge has fundamentally changed. We are witnessing what I call “**literature inflation**.” No matter what subfield you work in—AI, systems, or even interdisciplinary research—the flood of papers is overwhelming. It is literally impossible to read everything. Moreover, the *lifespan* of many papers has shortened dramatically. In earlier days, a

key paper might remain relevant for five or ten years; today, some are superseded within five months.

This makes the literature review process not just demanding but **strategically complex**. The question is no longer, “Can I read all the papers?” but rather, “Which papers are truly worth reading?”

To navigate this complexity, I find it helpful to apply a structured framework—what I call the **“Five W’s and One H.”**

1. **Who** – Identify the key people or groups leading the research in this area. Who are the pioneers? Which labs or individuals are consistently producing high-quality work? Recognizing the leading figures helps you anchor your understanding and follow reliable sources.
2. **Where** – Determine which universities, companies, or regions dominate this research. Sometimes, innovation clusters geographically. If a topic is pursued seriously only in one place, that’s a signal—it could mean either a highly specialized niche or a lack of broader interest.
3. **When** – Study the timeline. When did major publications in this area start to appear? Has interest grown or declined? This helps you assess whether the topic is emerging, peaking, or fading.
4. **What** – Understand the core problems, datasets, and methodologies being explored. What exactly are researchers trying to solve, and what are the competing approaches? Summarize and categorize the methods; this will give structure to your understanding.
5. **Why** – Reflect on the motivation behind the research. Why do people care about this problem? Is it driven by theoretical curiosity, practical applications, or social impact? Understanding the *why* grounds your own research relevance.
6. **How** – Examine how the research is done—the experimental designs, the theoretical frameworks, the datasets, the evaluation metrics. The “how” often reveals both the technical sophistication and the limitations of a line of work.

By systematically applying the **5W1H** lens, you transform your literature review from a passive reading exercise into an active process of *scientific mapping*. It allows you to see not just papers, but patterns—how ideas connect, evolve, and influence one another.

Identifying the Gems in a Sea of Papers

Despite the explosion of publications, it is worth noting that the number of **truly impactful papers** has not increased at the same rate. Much of what we see is repetitive, incremental, or short-lived. The real challenge—and responsibility—of a PhD student is to **identify the few works that genuinely advance the field**, technically or conceptually.

You must learn to separate the *signal* from the *noise*. Impactful papers often have certain traits:

- They introduce a new paradigm, tool, or dataset that others quickly adopt.
- They propose a method that remains relevant even as the field evolves.
- They inspire new lines of inquiry rather than merely closing an old one.

These are the papers you should study line by line, figure by figure, even re-implement if possible. Absorb their essence. Try to understand not only what they achieved, but why their ideas resonated with others. Doing so will refine your taste as a researcher—your ability to recognize what makes research *good*.

In a world where AI can summarize papers for you in seconds, your advantage will come not from reading faster, but from **thinking deeper**. Tools like ChatGPT or Gemini can generate literature summaries, but they cannot replace the human capacity for judgment, synthesis, and intuition. Those skills are cultivated only through slow, deliberate engagement with the material.

A good literature review is not a prerequisite step to research—it *is* research. It is the intellectual foundation upon which your PhD is built. By reading deeply, questioning actively, and filtering critically, you not only understand your field but start to **see yourself as part of its evolution**.

Remember: your goal is not to read every paper but to read the *right* papers well—to extract insight, context, and direction. When done properly, this process will give you something far more valuable than a bibliography—it will give you clarity, conviction, and confidence in your own voice as a researcher.

Embarking on Your Research Journey

Now that you have immersed yourself in the literature—reading over a hundred papers, studying fifty in depth, tracing authors' research trajectories, and understanding how their work shapes the community—it is time to **take the next step**: to embark on your own research journey.

This is the moment when your PhD begins to take form. Up to this point, you have been learning what others have done. From now on, you will start to define what *you* will do. It is both exciting

and daunting—the beginning of your first major research project, where you shift from being a reader of ideas to a creator of them.

From Literature to Action: Building Your First Research Project

The knowledge you have gained through your literature review is your compass. You now understand the landscape: where the frontier lies, which directions are promising, and where the gaps are. The challenge ahead is to chart your own path through this terrain.

A practical and effective way to structure your approach is to use **concrete papers as milestones**. Think of your research not as a single, monolithic task, but as a sequence of studies that build upon one another to form a coherent narrative. Each paper represents a small but significant step toward your final thesis vision.

1. Broad Scope with Specific Milestones

Your research theme should be **broad enough** to allow for multiple publications and follow-up directions, yet **specific enough** that each sub-problem can be tackled concretely. For example, suppose your general area is **indexing for data-intensive systems**.

You might structure your roadmap as follows:

- **Paper 1 – Foundational Stage:**
Design a novel indexing structure for static data. Establish the baseline, demonstrate the core idea, and validate its performance compared to known methods.
- **Paper 2 – Extension Stage:**
Explore how your indexing structure can be adapted to **dynamic data**—data that evolves or streams over time. Address update efficiency and real-time constraints.
- **Paper 3 – Scaling Stage:**
Investigate how the method performs under **large-scale or distributed settings**, focusing on scalability, fault tolerance, and system integration.

This approach allows your research to evolve naturally, giving you a sense of continuity while also producing tangible milestones along the way.

2. Develop a Visionary Roadmap

A strong PhD journey starts with **your own vision**. While your supervisor and peers will offer valuable advice, your research should not be a sequence of assignments—it should be a reflection of your curiosity, intuition, and sense of direction.

Discuss your ideas openly with your supervisor and group members, but take ownership of the vision. As my own advisor, **Dr. Qiong Luo**, often reminded me, *“Ideas are not judged by how many succeed, but by whether they connect toward a coherent goal.”* Even ideas that don’t lead to immediate success can contribute to the evolution of your research direction.

The important thing is to maintain a long-term view—to see how individual projects form part of a bigger picture. Visionary researchers think not just about their next paper, but about the story they want to tell through their body of work.

3. Generate and Evaluate Ideas Constantly

Idea generation should become a habit, not an occasional event. Every week, spend some time brainstorming possible extensions, variations, or new questions inspired by your ongoing work. At the same time, develop a **methodical way of evaluating** these ideas. Not every idea deserves full development; the skill lies in filtering the feasible from the premature.

Ask yourself:

- Is this idea new?
- Is it meaningful?
- Can I test it within a reasonable time frame?
- What data, computation, or theoretical tools would I need to explore it?

This iterative process keeps your thinking sharp and prevents intellectual stagnation. Over time, you’ll learn to recognize which ideas have the most potential impact and which are better left as notes in your research diary.

4. Execution Strategy and Iterative Refinement

Once you’ve selected a viable idea—your **Paper 1 milestone**—the real work begins. Start by outlining your methodology and planning your experiments. At this stage, it’s perfectly acceptable to **learn by imitation**. Analyze how successful papers you studied were structured: How did they pose their problem? How did they visualize results? How did they argue significance?

In the early stages of your PhD, imitation is not a weakness—it's an essential step in developing your research instincts. Over time, your style and originality will naturally emerge.

Apply a **divide-and-conquer strategy** to manage complexity. Break large problems into smaller, manageable parts. For example, when designing a system, first test it on simplified settings or smaller datasets before scaling up. This incremental refinement builds confidence and helps you troubleshoot systematically.

5. Integration with Larger Research Goals

Finally, always situate your research within a **broader context**. Understand how your work aligns with your research group's focus and how it contributes to the field's ongoing discourse. This not only strengthens the relevance of your project but also helps you build connections and visibility within your academic community.

In my own research group, for example, we focus on building systems that improve **efficiency, scalability, and energy sustainability**—the infrastructure that empowers other AI researchers. This philosophy—*building the shovels and water pipes during the gold rush*—has guided much of our success and impact. It ensures our work remains useful and adaptable even as trends change.

The Role of Perspective and Patience

At this stage, it's crucial to cultivate a **big-picture mindset**. Every research idea you pursue should fit within a logical and evolving scope. The best topics are those that can support **three to four coherent papers** leading up to your thesis. Discuss this roadmap with your supervisor early on, refine it periodically, and stay flexible—some branches will grow faster than others, and some may naturally fade.

Don't rush. The early months of your research are like planting seeds. You may not see immediate results, but your thoughtful groundwork will pay off later when your publications and thesis come together as a consistent, mature body of work.

Checklist: Guiding Questions for Literature Review and Topic Selection

To help you systematically evaluate the literature and identify a strong research direction, here is a practical checklist of questions. You can use this both when reading papers and when narrowing down your topic.

A. Understanding the Landscape

1. **Who** are the leading authors and research groups in this area?

2. **Where** are the top institutions or labs producing impactful work?
3. **When** did key developments begin, and how has the field evolved over time?
4. **What** are the main research questions and methodologies?
5. **Why** is this topic important or gaining attention now?
6. **How** are current approaches being evaluated (datasets, metrics, user studies, etc.)?

B. Evaluating Research Gaps

7. What limitations or open problems are most frequently mentioned?
8. Are there assumptions in current research that could be challenged or relaxed?
9. Are there domains (finance, healthcare, systems, etc.) where the techniques could be extended or adapted?
10. What are the most cited or benchmark papers in this field—and what remains unsolved since then?

C. Aligning with Your Strengths and Interests

11. Which subtopics genuinely excite you or match your skills?
12. Which directions can realistically yield 2–3 strong papers over your PhD timeline?
13. Do you have access to the data, hardware, or collaborations needed to pursue this topic?
14. Is this area too saturated, or is there still space for innovation?

D. Assessing Impact and Sustainability

15. Will this research still matter five years from now?
16. How could your results translate into open-source tools, systems, or community benchmarks?
17. Could your research benefit other researchers or practitioners beyond academia?

By reflecting on these questions, you move from passively absorbing knowledge to actively designing your research path. Remember, a great PhD is not built on chance—it's built on **clarity, consistency, and curiosity**.

Additional Considerations: The Long Game of Research

At this point, it's worth emphasizing several broader reflections on how to sustain yourself through the research process. Many students imagine that a good research idea arrives like a lightning strike—sudden, brilliant, and final. In reality, research rarely unfolds this way. It is not a one-shot attempt, but a long, **iterative and cyclical journey**.

1. Research as an Iterative Process

Developing a strong research idea is best understood as an ongoing cycle rather than a linear path. You begin with **brainstorming**—collecting seeds of ideas that spark curiosity. Then, through preliminary reading, discussions, and small experiments, you gradually refine them. Some ideas will fail early, others may evolve into more mature directions. The process loops: review → test → reflect → refine → repeat.

It is important to accept that you **won't get it right on the first try**, and that's perfectly fine. In fact, the best ideas are often born out of several failed attempts. Each cycle teaches you something new—how to evaluate feasibility, how to detect novelty, and how to position your ideas strategically.

In my own experience, many successful PhD projects did not start as grand visions but as small, uncertain prototypes that evolved over multiple rounds of rethinking and reshaping. The key is to **keep moving forward**—even a small iteration each week compounds into meaningful progress over time.

2. Learning from Repetition and Discovery

The nature of research is inherently challenging. It often takes more than ten iterations—sometimes dozens—to polish an idea to publication quality. You might spend weeks developing what you believe to be a novel concept, only to discover that someone else published something similar years ago.

While frustrating, this moment should be viewed as a **milestone, not a setback**. It means you are finally reaching the edge of existing knowledge—the boundary where real research begins. Every time you rediscover a known result, you gain a deeper appreciation for the field's structure and logic. Each “duplicate idea” sharpens your intuition about what truly constitutes novelty.

In the long run, these cycles of exploration and rediscovery train your **research instincts**—the quiet ability to sense what's worth pursuing and what's likely well-trodden. That intuition is one of the most valuable skills a PhD can cultivate.

3. Finding Your Own Rhythm

Another key to sustaining creativity is to **find your own research rhythm**. People think differently, and the conditions for deep thinking vary widely from person to person. Some students find clarity during long walks, others while jogging, showering, or cooking.

Personally, I've noticed that many of my best ideas emerged not in front of the computer but in moments of quiet reflection—on a plane, in a café, or during a late-night stroll. The mind often works best when it's slightly detached from the problem, allowing unconscious reasoning to surface.

You don't need to copy anyone else's routine. Instead, pay attention to when your mind feels most creative and alert, and build habits around those moments. Whether it's sketching ideas in a notebook after a morning run or discussing thoughts with peers over coffee, **create your own rituals of reflection**. Over time, these habits become the rhythm that sustains your entire research life.

4. Managing Time and Momentum

Research success is not only about intelligence or creativity—it's also about **time management and disciplined execution**. Unlike coursework, where deadlines are fixed, research deadlines are mostly self-imposed. This freedom is both empowering and dangerous: without structure, it's easy to drift.

To maintain momentum, set **clear short-term and long-term goals**. For example:

- By the end of this week, I will reproduce the baseline experiment.
- By the end of next month, I will have a draft of my experiment section.
- By the end of this semester, I will aim for a submission-ready version of my paper.

Each goal should be realistic but firm. Visualize progress as a sequence of milestones rather than a single finish line. Reaching small goals regularly not only boosts confidence but also builds a rhythm of productivity that makes large achievements feel attainable.

Equally important is knowing when to **pause or pivot**. Give yourself a **reasonable time window** to explore a new idea—say one or two weeks. If, after genuine effort, you still cannot find a viable direction or convincing novelty, it's okay to stop and move on. This is not giving up—it's strategic withdrawal. Research time is precious; learning when to cut losses is as crucial as persistence.

5. Setting Boundaries and Deadlines

While perseverance is essential, unbounded perseverance can become counterproductive. A good researcher knows how to balance *patience* with *decision-making*.

If you are exploring a new topic, discuss with your advisor or collaborator and agree on a **deadline for evaluation**—perhaps one month to see if the idea shows potential. Break this into weekly checkpoints. If progress stagnates or the topic proves infeasible, have the courage to step back and redirect your energy.

This approach ensures that exploration remains purposeful rather than endless. Remember, flexibility is not inconsistency—it's adaptation. The ability to **pivot gracefully** when needed is one of the defining qualities of a mature researcher.

6. Adaptation: The Only Constant in the AI Era

In today's AI-driven research environment, adaptation has become the **new survival skill**. The landscape changes at unprecedented speed: what was state-of-the-art last year may already be obsolete today. New tools like large language models, autoML systems, and open-source datasets constantly reshape what's possible.

Therefore, cultivating adaptability—both in mindset and method—is vital. Stay curious about emerging trends, but don't chase every new wave blindly. Instead, develop the habit of regularly reassessing your topic and methods. Ask: *Is this still the best way to answer my research question?* or *Has new technology opened a better path?*

Adaptation also means continuously updating your knowledge and skills—learning new tools, programming languages, or experimental frameworks as needed. The researchers who thrive are not those who know everything, but those who can **learn anything, quickly**.

7. The Iterative Spirit Beyond the PhD

Finally, it's important to realize that this iterative process—brainstorming, refining, adapting—is not limited to your PhD years. It will accompany you throughout your entire research career. Even as a faculty member or industry scientist, you will continue this cycle of exploration and reflection.

The real goal of doctoral training is not just to produce a few papers—it's to internalize the **habit of curiosity-driven iteration**. Once you learn to approach uncertainty with patience, persistence, and adaptability, you'll find that research becomes less about "solving" and more about *discovering*.

As I often tell my students:

"The best outcome of your PhD is not your thesis—it's the way you learn to become an independent researcher."

That mindset—the willingness to iterate, adapt, and grow—is what will sustain you far beyond your graduation day.

Writing Your Qualifying Exam (QE) Report

Once you have completed your **survey paper** and your **first research paper**, you are in an excellent position to begin assembling your **Qualifying Exam (QE) report**. This report is more than a compilation of your past work—it is your opportunity to **present a coherent picture of your research journey**, demonstrating that you have mastered the foundational knowledge in your area and are ready to conduct independent research.

Think of your QE report as a bridge between exploration and consolidation. It connects the early stage of curiosity-driven discovery (literature review, idea generation, early experiments) to the later stage of structured, vision-driven research (proposal, thesis, publications). A well-prepared QE report signals to your committee that you are not just following your supervisor's direction—you are beginning to lead your own intellectual path.

Structure of the QE Report

While the exact format may vary slightly across universities or departments, a clear and systematic structure will greatly strengthen your report. Below is a recommended outline that integrates both your survey and research outputs into a coherent whole.

1. Introduction (at least 5 pages in thesis format)

Your introduction is the reader's first encounter with your research world. It should do more than describe a problem—it should **tell a story**: what inspired this direction, why it matters, and how your work fits within the broader scientific landscape.

Key components to include:

- **Problem Statement:** Clearly define the problem your research addresses. Avoid overly general statements; instead, focus on the precise technical challenge you aim to solve. Explain why this problem is non-trivial and significant.
- **Motivation and Context:** Why does this problem matter to the research community or industry? Link it to real-world implications or fundamental scientific challenges.
- **Your Early Contributions:** Briefly describe what you have achieved so far, drawing on the results from your first research paper. You can integrate some of the introduction from your paper here, but adapt it to the QE tone—this is about the *bigger picture*, not just one experiment.
- **Connection to Literature:** Enrich the introduction by blending insights from your survey paper. For example, highlight how your literature review revealed certain open problems

or inconsistencies that led you to your current direction.

- **Future Work and Vision:** End the introduction by outlining what lies ahead. This section signals to your committee that you not only understand what has been done but also have a clear sense of *where to go next*.

The introduction sets the tone for the entire QE report—it shows maturity of thought, the coherence of your research narrative, and your awareness of the long-term impact of your work.

2. Literature Review (at least 10 pages in thesis format)

This is often the longest and most technically dense part of the QE report. It reflects both the **breadth of your reading** and the **depth of your understanding**.

You can use your **survey paper** as a starting point, but this section must go beyond summarization. It should demonstrate that you can synthesize trends, identify gaps, and organize existing knowledge into a meaningful structure.

Practical tips:

- **Structure by Theme or Dimension:** Instead of summarizing papers one by one, group them into conceptual clusters. For instance, if your topic is *graph processing on GPUs*, your sections might include *static graph frameworks*, *dynamic graph frameworks*, *load-balancing strategies*, and *heterogeneous memory models*.
- **Contextualize State-of-the-Art (SOTA):** Highlight the key papers and frameworks that define the current frontier. A comparative table summarizing key results—e.g., system design, scalability, energy efficiency, or throughput—can make your analysis more digestible.
- **Use AI Tools Wisely:** At this stage, tools like ChatGPT's **Deep Research** or connected literature databases can assist in generating comprehensive coverage and identifying new papers. However, remember that *AI can summarize content, but only you can provide insight*. Use these tools for data gathering, not for thinking.
- **Be Selective:** While it's important to demonstrate coverage, do not drown the reader in details. Focus on papers that truly shaped the field or influenced your direction.
- **Highlight Research Gaps:** Conclude this section by clearly stating what is missing in the existing body of work and how your research is designed to fill that gap.

A strong literature review not only informs but *positions* your research—it defines the intellectual space you will occupy.

3. Exposition of Your Research (Paper One and Beyond)

This section forms the heart of your QE report. Present your research contributions in a concise, structured, and formal manner.

If you already have a published or submitted paper, you can integrate it here **with minor adjustments**.

- Update phrasing from “in this paper” to “in this qualifying exam.”
- Expand where necessary to clarify design decisions, experimental details, or reflections that were omitted in the original conference version.
- Include additional discussions on lessons learned or unexpected findings—elements that are often too informal for a publication but valuable in a QE context.

If you have started a **second research project**, you may include it as a secondary section (Paper Two), again with formatting and contextual alignment. The goal is to show *progression*: how Paper Two builds logically on the foundations of Paper One.

4. Conclusion (around 1 page)

Conclude by summarizing the key contributions and insights of your research so far. Restate the significance of your work and its alignment with the broader research agenda of your field.

This section should leave the reader with the impression that your work is not an isolated project but a building block in a longer, meaningful trajectory.

5. Future Work and Thesis Roadmap (around 3–4 pages)

Perhaps the most important part of your QE report, this section projects your **vision for the next two to three years**. Note, not a simple future work for your paper one. It should be something broad enough so that you want to explore in the coming 3-4 years.

Outline your planned directions, potential experiments, and expected milestones. A typical roadmap might include:

- Refining or extending your current prototype to handle new scenarios.
- Integrating novel methodologies or cross-disciplinary insights.

- Collaborating with other research groups or applying your techniques to new domains.
- Planning the timeline: when to address each major task, when to submit the thesis proposal, and when to target the thesis defense.

Also, discuss **anticipated challenges** and mitigation strategies. Acknowledging potential risks shows maturity and foresight—it demonstrates that you are thinking critically about how to navigate uncertainties.

Writing Tips and Formatting Guidelines

A professional presentation strengthens the credibility of your work. Here are some practical guidelines for adapting your materials into QE format:

1. Terminology Adjustments:

Replace terms like “in this paper” with “in this qualifying examination” or “in this study.” It signals that you are presenting cumulative research, not a single publication.

2. Chapters vs. Sections:

Treat major divisions as **chapters**, not mere sections, to reflect the report’s formal structure and its role as a precursor to your thesis.

3. Formatting Figures and Tables:

Research papers often use a double-column layout, while QE and theses are typically single-column. Reformat your figures and tables accordingly, and ensure readability by adjusting text sizes and captions.

4. Reference Management:

Update citations to reflect their formal publication venues where possible. For preprints or arXiv papers, verify if they have since appeared in a peer-reviewed conference or journal. Consistency in reference formatting demonstrates professionalism.

5. Language and Tone:

The QE report should read as a *scholarly narrative*, not as a compilation of disjointed manuscripts. Ensure smooth transitions between chapters, consistent terminology, and a unified writing voice.

Final Reflections: The QE as a Milestone of Maturity

Writing your QE report can be both intimidating and rewarding. It demands synthesis, reflection, and foresight—three qualities that define a mature researcher.

You are no longer merely consuming knowledge but **constructing your own intellectual framework**. The QE process forces you to articulate *why* your work matters, *where* it fits, and *how* it will evolve.

When done thoughtfully, your QE report becomes more than a requirement—it becomes a **blueprint for your PhD thesis** and, in many ways, your first major academic contribution as an independent researcher.

So take the time to craft it carefully. Seek feedback, revise iteratively, and make it your own. Years later, when you look back, you will find that writing your QE report was not just a checkpoint—it was the moment you truly began to think like a scientist.

The last but not the least. Please maintain a reading list in GitHub.

Feedback?

Please send your comments to Bingsheng He, hebs@comp.nus.edu.sg.

Appendix: Maintaining a Living Literature Review

When I look back on my own PhD journey, I realize that the most valuable habit I developed was not coding faster or writing more pages — it was the quiet, consistent effort of keeping my literature review alive. A living literature review is more than a record of what others have done; it is the evolving history of your own intellectual growth. Every time you revisit it, you see how your understanding deepens, how your field shifts, and how new connections emerge between once-disparate ideas.

In fast-moving areas like AI, systems, and data management, knowledge has a short half-life. A paper that was state-of-the-art a year ago can become a footnote today. Without an updated view of the field, you risk reinventing what is already known — or worse, spending months on a problem that others have just solved. Keeping your literature review “alive” means protecting your research from obsolescence.

A good literature record also preserves *history with context*. You see not only *what* was proposed, but *why* it mattered at that time. This historical awareness helps you understand why some ideas succeeded, others faded, and what the next turn of innovation might be. It teaches humility — realizing how many good ideas existed before you — and it builds vision, because you start recognizing the invisible threads that connect the past, present, and future of your research domain.

In the AI era, the tools for maintaining this living record have multiplied. Automation can now take care of routine discovery — Google Scholar alerts, Semantic Scholar feeds, arXiv digests — but interpretation still requires a human mind. AI can summarize a paper, but only you can

judge whether it truly shifts your understanding. The real power comes from combining both: using AI to track breadth, and your own critical thinking to sustain depth.

A Practical Checklist for a Living Literature Review

Below is a short, actionable checklist that I encourage every graduate student to adopt. You can adapt it to your own workflow.

1. Discovery and Update

- Subscribe to alerts (Google Scholar, Semantic Scholar, arXiv) for key topics and authors.
- Check top-tier conference acceptance lists (e.g., SIGMOD, VLDB, NeurIPS, ICLR) after each cycle.
- Allocate 30 minutes weekly to skim abstracts and mark 2–3 papers for deeper reading.

2. Organization and Recording

- Maintain a Zotero or Mendeley library with tags for topic, method, and dataset.
- Keep a shared Google Sheet or GitHub repository (e.g., *Awesome Federated Learning*) with:
 - Title, authors, venue, PDF/code link
 - Three-line summary of main contribution
 - Notes on relevance to your own project
- Update `.bib` files regularly to reflect the latest peer-reviewed versions.

3. Reflection and Mapping

- For each paper, jot down: *What problem does it solve? What assumptions does it make? What remains open?*
- Build a simple mind map connecting papers to your ongoing work and future ideas.

- Revisit this map monthly — ask: *Has anyone already done what I planned as future work? If yes, how can I pivot?*

4. Collaboration and Sharing in Github

- Share your reading list with your supervisor and teammates in GitHub (like some awesome list).
- Present one interesting paper each month in a group meeting.
- When possible, make your reading repository public — it contributes to the community and signals leadership.

5. Automation and AI Support

- Use AI tools to help summarize or cluster papers, but always verify the details.
- Let AI suggest related work, then manually refine the selection for accuracy and relevance.
- Automate reminders — for example, a bi-weekly task that prompts you to check for new citations.

6. Periodic Review

- Every 3–4 months, write a one-page summary of “what changed” in your field: new datasets, benchmarks, or paradigms.
- Incorporate this reflection into your thesis notes or Qualifying Exam report — it saves enormous time later.