IEEE PCS Professional Engineering Communication Series
Ryan K. Boettger, Series Editor

SO, YOU HAVE TO

A GUIDED WORKBOOK

WRITE

FOR ENGINEERS

A LITERATURE REVIEW

CATHERINE G.P. BERDANIER | JOSHUA B. LENART

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So, You Have to Write a Literature Review

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Contents

A Note from the Series Editor

Stop me if you have read this before: the skills acquired by students in STEM majors often conflicts with industry's expectations of skills.

Industry wants employees who not only have technical expertise but also the ability to clearly communicate that expertise. Meanwhile, academics are adjusting their programs to reflect their institution's initiatives to recruit and retain students and simultaneously expand their degree plans with math and science courses that meet external accreditation requirements. Though STEM program directors and professionals share a mutual goal – to produce and to hire the best technical talent – their paths toward achieving that goal often appear disparate.

Within this broader issue are conversations on the need for and placement of soft skills in STEM curricula. A 2018 survey found that STEM industry leaders identified communication skills as the most important in their fields. In fact, half of the highest ranked skills were considered soft skills: communication, work ethic, problem solving, team work, and analytical skills [1]. This does not mean that technical skills are not important to industry practitioners, but there seems to be a perception that soft skills (as well as managerial skills) play an increasingly important role in industry. This perception is further complicated by the findings that STEM majors do not always find value in improving their soft skills [2].

In engineering fields, writing is typically taught as a general elective requirement for undergrads, while relatively little (if any) required curricular time is focused on discipline-specific writing at the graduate level [3]. In addition to a lack of writing instruction in STEM degree plans, we need to acknowledge the writing exposure our students received before they even entered a college classroom. Students in North American and European elementary and secondary schools are typically exposed to writing that only reflects the "'approved cannon' of literature common to most English classrooms" [4, p. 97]. This writing is characterized as expository and encourages developing writers to describe, reflect, and explain ideas in the forms of essays, reflective pieces, and short stories. These are not necessarily incorrect ways to teach writing, but they do condition developing

writers to communicate in ways that may not reflect the situations they will encounter in the workplace.

It is not surprising then that the literature review, which requires writers to establish credibility not through their own personal insights and opinions but with a persuasive presentation of scholarly research, remains an unfamiliar and elusive text type to many STEM students. Before the actual writing can even begin, writers have to identify and sift through a seemingly unmanageable amount of information. Then they synthesize, paraphrase, and generalize that information to build credibility and establish ownership of their own ideas. Anyone tasked with writing a literature review has undoubtedly found it an arduous process, but I assume you already know this. It is why you chose this book. Maybe you are a Masters student about to start your thesis, or perhaps you are an advisor who needs a comprehensive guide for your students. Whatever your reason, you have no better coaches than Catherine G.P. Berdanier and Joshua B. Lenart.

I met Catherine and Joshua at their presentation at the 2017 IEEE International Professional Communication Conference [3]. I typically attend conference panels on curriculum development and assessment, but I rarely leave those panels feeling particularly informed or inspired. Just as there is a stigma attached to the value in acquiring soft skills, there is a perception that pedagogical research is lightweight and inconsequential. Unfortunately, the related research in technical and scientific communication does little to combat this perception: the recommendations from these studies are often informed by self-report, lacking generalizability outside a single instructional setting. My own advisor equated these scholarly endeavors with having a cup of coffee with a colleague – the experience is often enjoyable and instantly gratifying, but the resulting recommendations are not sustainable and only as useful as chatting about an experience over a cup of coffee [5].

But rather than just describing their own experiences, Catherine and Joshua presented an instrument that engineering students could use to self-evaluate the structure and style of their own literature reviews. Their framework was inspired by moves-steps analysis, and their discipline-specific, non-reductionist, easy-to-follow coding scheme was refined from testing across multiple instructional sites and student populations. The scholarship that Catherine and Joshua conduct acknowledges engineering students' limited instruction in academic and technical writing and then builds from those realities to improve their communication competences.

This book offers a sampling of the rich data that Catherine and Joshua have collected throughout their careers. They scaffold learning appropriately with authentic examples and student-tested activities. They deliver content that is easy for students to digest but substantial enough for advisors who require a comprehensive text on the subject.

I remain committed to bringing you quality, accessible content with this series. In particular, the support from both the Wiley Press and IEEE teams make this commitment a privilege. I would also like to acknowledge the contributions of Austin Goodwin whose work has helped me rebrand this series and freshen the perceptions of professional communication. As always, I have amazing support from the Department of Technical Communication at the University of North Texas and my chair Kim Sydow Campbell. Finally, to my son Liam West – we have not met yet, but I am already in love.

Ryan K. Boettger, PhD

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About the Authors

Dr. Catherine Berdanier is an Assistant Professor of Mechanical Engineering in the Department of Mechanical Engineering at Pennsylvania State University at University Park. She holds an MS in Aeronautical Engineering and a PhD in Engineering Education from Purdue University. Her research focuses mainly on graduate-level engineering education with emphasis on engineering writing and communication, attrition, and persistence. Her research has been funded through multiple NSF awards. She is the Director of the Engineering Cognitive Research Laboratory (E-CRL), where she and her graduate students investigate questions concerning the human side of engineering through a variety of quantitative, qualitative, experimental, and analytical methods.

Dr. Joshua Lenart is an Associate Instructor with the Communication, Leadership, Ethics, and Research (CLEAR) Program at the University of Utah where he also received his PhD in Writing and Rhetoric Studies and now teaches technical communication for the College of Engineering. His teaching expertise includes administrative and organizational writing, grant writing, teambuilding, and strategic communications. His research expertise focuses on natural resource management policy as it relates to landscape-scale impacts on wildlife habitat, hydrologic systems, community resilience, adaptation planning, and long-term land-use conservation. For the past five years, he has led various transdisciplinary research projects examining land, water, and wildlife resource management conflicts vis-à-vis policy, stakeholder input, feasibility and environmental impact assessment, and collective impact engagement.

Acknowledgments

Our partnership began as many collaborations do: at lunch in a café, in between conference sessions, comparing notes on teaching graduate student engineering writing. We thank each other for leveraging our unique disciplinary backgrounds and cumulative decades-worth of experiences teaching academic writing to graduate engineering students. We thank our editor, Ryan Boettger, for approaching us to write for this book, and helping us see it through. Of course, projects of this size are not possible without a number of other people in our lives we'd like to acknowledge.

Catherine would like to thank:

Her students: past, present, and future, for opening up about their difficulties with writing such that she can craft more effective resources for graduate engineering writers. Special thanks go to the students whose excerpts are employed as examples in this book.

Her research team for reading the "Ugly Drafts" and giving feedback from the student point of view.

Her colleagues and friends at Penn State and across the country who support her and offer sanity and sound advice.

This book is dedicated to her family: Reid, Jacob, and the forthcoming baby (who did not contribute at all, really, but kept her company during final edits!)

Joshua wishes to thank:

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His parents, Robert and Gwendolyn, who were always loving and always pressuring him to be better, but, above all, taught him to be independent.

His wife Tanner and his daughter Cora – whose love, patience, and grace mean everything.

About the Book

Is a literature review looming in your future? Are you procrastinating on writing a lsiterature review at this very moment? If so, this is the book for you. Writing often causes trepidation and procrastination for engineering students – issues that compound while writing a literature review, a type of academic writing most engineers are never formally taught. Consider this workbook as a "couch-to-5k" program for engineering writers rather than runners: if you complete the activities in this book from beginning to end, you will have a literature review draft ready for revision and content editing by your research advisor.

So, You Have to Write a Literature Review presents a dynamic and practical method in which engineering students – typically late-career undergraduates or graduate students – can learn to write literature reviews, and translate genre-based writing instruction into easy-to-follow, bite-sized activities and content. Written in a refreshingly conversational style while acknowledging that writing is quite difficult, Catherine Berdanier and Joshua Lenart leverage their unique disciplinary backgrounds with decades of experience teaching academic engineering writing in this user-friendly workbook.

How to Use This Book

(Hint: These pages are important. You probably want to read them.)

We predict that because you are holding this book, reading these words, there is a strong probability that you are an upper-level undergraduate student or a graduate student who is fast-approaching a deadline for a senior project, thesis, or dissertation. There is also a chance that you fall into the rare type of engineer who enjoys writing, but more likely you may not like to write, or read all that much, either. There is also a high likelihood that you are a bit panicked about writing a literature review, and an even higher chance that you typically find yourself procrastinating on writing. We get it. We were both there in the not-so-distant past and now we work with students every semester who are in the exact same position that you find yourself in now. We have seen our students advance to fabulous careers, win prestigious awards, and travel to interesting places. We have also watched these same students stressed, frustrated, and occasionally in tears while working through the writing process.

We are here to help.

When we set out to write this book, we wanted to create a hands-on, easy-to-use workbook that facilitated the writing of a literature review in lieu of one of our classes, such that if students worked through the book, completing the materials from beginning to end, they would have a decent working draft to submit to their advisor.

Learning to write, as with any activity, takes time. Your timeline might vary, so we propose several timelines for completing this book and its activities: a 32-week plan, a 16-week plan, an 8-week plan, and (and only as a last resort) a 1- and 2-week *Help!* plan for those of you who accidentally procrastinated a little too vigorously.

Think of this workbook as you would your lab book. This is not a book to sit down and skim through once over a weekend and then launch into writing your literature review. Rather, we want you to write in it and dog-ear important pages. After years of helping engineering students improve their writing, we have found

that when students respond to activities or write notes with a pen or pencil, they more easily focus their attention on smaller bits of the writing process rather than being overwhelmed. The activities in this book are designed to arrive to you *just at the time when you need them*, helping you focus your mind and time between composing tasks (i.e. thinking new thoughts and translating them into words) and revising/editing tasks (i.e. delivering those new thoughts in a clear, concise, and grammatically correct format). In writing subsequent literature reviews, you will not need to redo the learning activities or the deep discussions again as you will have developed more confidence and competence in writing.

As such, we have devised four plans for beginning and (more importantly) *completing* your literature review that is based on your timeline. You can also interpolate between plans to arrive at a plan that meets your personal goals. The 16-week and 8-week plans are the most popular and reasonable plans for students to undertake. We provide distributed timelines for book completion to help you with accountability and time management – just like in a class.

I.1 The 32-Week Plan

This plan is devised only for doctoral students writing a dissertation, who may be working thorough literature review over a long period of time. If you are reserving a significant amount of time to thoroughly review the literature for a PhD proposal or for the dissertation itself, this plan is for you (Table I.1). However, skip to a shorter plan if (i) you do not have 32 weeks, (ii) you need to keep momentum to finish a project, or (iii) the literature review you are writing is not intended to be comprehensive (covering all salient literature associated with your project). For this plan, you will spend a significant amount of time on Chapters 3–7. Once you establish a pattern for how you review a particular piece of literature, you will apply that same method to all subsequent articles or books you read.

Table I.1 Sample 32-week plan for completing this book.

Week(s)	Chapters	Week(s)	Chapters
1	1	17–20	7
2	2	21–22	8
3–5	3	23–24	9
6–8	4	25–28	10
9–11	5	*29–30*	*Advisor review*
12–16	6	31–32	11

I.2 The 16-Week Plan

This plan is the most common for students who are writing a longer literature review, such as for a thesis or dissertation. A shorter literature review, like one required for a journal or conference paper, may be more suitable for the *8-week plan*. Here is a typical schedule for a 16-week plan, but adapt it for your circumstances (Table I.2).

I.3 The 8-Week Plan

This is the fast track plan. This plan is for you if you are (i) highly motivated to complete your project in a timely manner, (ii) approaching a draft submission deadline, (iii) already in the midst of reviewing literature and have been keeping a running account of the works you have already reviewed, or (iv) completing a professional paper or project that does not have to be as long as a traditional thesis or dissertation.

If you are on a quarterly academic calendar and would like to spend one quarter writing a literature review, you can work from the 8-week plan and expand it slightly to meet your timeframe (Table I.3). You will breeze through

Table I.2 Sample 16-week plan for completing this book.

Week(s)	Chapters	Week(s)	Chapters
1	1 and 2	9 and 10	7
2 and 3	3	11 and 12	8
4 and 5	4	13 and 14	9
6 and 7	5	15 and 16	10
8	6	*After advisor review*	*11*

Table I.3 Sample 8-week plan for completing this book.

Week(s)	Chapters	Week(s)	Chapters
1	Chapters 1–3	5	Finish Chapter 7
2	Chapter 4	6	Chapter 8
3	Chapter 5	7	Chapter 9
4	Chapter 6 and start Chapter 7	8	Chapter 10
		After advisor review	*Chapter 11*

some chapters (1 and 2) quickly. Other chapters (3–7), will take more time, but do not neglect the time that revision and honing takes (9 and 10). Here is a recommend schedule.

Those attempting the 8-week plan must do so confidently; you must work diligently nearly EVERY DAY with only occasional days of rest. There is no alternative here; if you do not write nearly every day, even if only for 30 minutes, then you and your advisor – who has likely assigned you this task on this timeline – are likely to be frustrated with each other by week 8. The frustration often stems from the fact that advisors can write literature reviews quite swiftly themselves, having been steeped in the literature for some time and also having developed effective personal writing strategies. Since students are generally *learning* how to do these supporting tasks at the same time as practicing them, it usually takes students much longer to write literature reviews than their advisors imagine. Idealistic 2-month timeframes for writing literature reviews without guidance are common, but we rarely see them accomplished effectively. This book will help facilitate the process, but it will still require daily working and writing sessions.

I.4 The "Help!" Plans (1-Week and 2-Week Triage Plans)

First things first. Tell your roommate, partner, or whomever you spend a lot of time with that they will not be seeing much of you before the deadline. And by "will not be seeing much of you" we mean, of course, maybe they will see you for a couple of minutes as you stumble into bed, bleary eyed, before having to wake up and do it again tomorrow. We have all been there, but let this book help you realize that there are distributed ways to making this process not as painful next time. Next time you have to write a literature review, choose one of our other plans and complete the activities in this book in the way designed, breaking the cycle of procrastination and negative experiences with writing.

If you have to write a literature review in a week – good luck. We created an amended 1-week timeline for working through only the most core activities in the book (Table I.4). Note that we removed a lot of content and offered additional notes about which activities you should complete and which you can ignore. At this stage, you will skip Chapter 1 and most of Chapter 2, instead skipping straight to Chapter 3. You will barely skim Chapters 9 and 10, which are about revision and common *faux pas*, but you will likely return to them (in depth) when you receive feedback and edits from your advisor.

If you have a bit more time or you can ask for a 1-week extension (hey, it is worth a shot), follow the 2-week plan (Table I.5). It is still an enormous push, so

Table I.4 Sample 1-week (7-day) plan for completing this book.

Day(s)	Chapters	Notes
1	Section 2.1 Chapters 3 and 4	**Chapter 2** • Skim Section 2.1. **Chapter 3** • Skip Activity 3.1. • Skip the Parts of Activity 3.3 and others requiring you to ask around: do not ask around, just make a decision and move on. • Modify Activity 3.6: As you are skimming literature, make note of how many references and approximately how long the literature review sections are to develop a sense of the norms in your discipline. **Chapter 4** Skip Activity 4.1 – You will only have the time to skim literature; Start reading at Section 4.2. Spend time on the Annotated Bibliography (Section 4.5 and Activity 4.2) to remember what you are skimming. To help you control your focus, keep track of three main things for each article in your annotated bibliography: (i) the authors' research questions, (ii) the broad methods they are using (not the specifics), and (iii) what their primary findings were and ramifications for the field.
2 and 3	Chapters 5 and 6	**Chapter 5** • Skip Activity 5.1. • Do Activity 5.2 using the notes from your annotated bibliography. To save time, do not use sticky notes – jump to our suggestions for working in a word processing document in the "Alternate Activity" at the bottom of Activity 5.2. • Read Sections 5.2–5.4, but skip the embedded Activities 5.3–5.6. **Chapter 6** • Complete Activity 6.1. • Skip Activity 6.2. • Complete Activity 6.3 in Word, using your work from Chapter 5, to help you develop a rough outline.
4 and 5	Chapter 7	• Skip Sections 7.2 and 7.3. • Skip Activity 7.1.
6	Chapter 8	Read this chapter and use it to help you continue to hone your literature review as you continue skimming literature and synthesizing the literature together.
7	Skim Chapters 9 and 10	Skim these chapters. Use them to do light editing (you will not have much time), but you will likely use them more after you get feedback on your draft.
After advisor feedback	Chapters 9–11	

Table I.5 Sample 2-week (14-day) plan for completing this book.

Day(s)	Chapters	Notes
1	Chapters 2 and 3	**Chapter 2** • Skim Chapter 2. **Chapter** 3 • Skip Activity 3.1. • Skip the Parts of Activity 3.3 and others requiring you to ask around: Do not ask around, just make a decision and move on. • Modify Activity 3.6: As you are skimming literature, make note of how many references and approximately how long the literature review sections are to develop a sense of the norms in your discipline.
2–4	Chapter 4	For the sake of time, skim most of your articles, selecting only the most relevant to read in depth. Spend most of your time working on your annotated bibliography (Section 4.5 and Activity 4.2) to remember what you are skimming/reading. To help you control your focus, keep track of three main things for each article in your annotated bibliography: (i) the authors' research questions, (ii) the broad methods they are using (not the specifics), and (iii) what their primary findings were and ramifications for the field.
5	Chapter 5	• Skip Activity 5.1. • Do Activity 5.2 using the notes from your annotated bibliography. To save time, do not use sticky notes – jump to working in a word processing document. • Read Sections 5.2–5.4, but skip the embedded Activities 5.3–5.6.
6	Chapter 6 and start Chapter 7	**Chapter 6** • Complete Activity 6.1. • Skip Activity 6.2. • Complete Activity 6.3 in word processing program, using the work from Chapter 5, to help you develop an outline. **Chapter 7** • Start working through Chapter 7 to build out your literature review. • Skip Sections 7.2 and 7.3. • Skip Activity 7.1.
7 and 8	Finish Chapter 7	Continue and finish Chapter 7 to build out your literature review.

Table I.5 (Continued)

Day(s)	Chapters	Notes
9 and 10	Chapter 8	Read the chapter in the morning; use your knowledge to drive your writing and revising processes throughout the day.
11 and 12	Chapter 9	Read the chapter in the morning; use your knowledge to drive your writing and revising processes throughout the day.
13 and 14	Chapter 10	Use this checklist to guide your revision before the deadline.
After advisor feedback	Chapter 11	

carefully follow our suggestions on which activities to complete and which to ignore (for now).

During this crunch time, we have some cautions for you. We urge you to pay attention to Section 3.5 on how to effectively use reference managers: especially at the last minute, time spent downloading a good one will be well spent. They are useful in case you accidentally format everything in APA and it needs to be in IEEE. We recommend using a free software (like Mendeley) that includes features that allow you to upload an entire batch of literature quickly, that links to your computer files to auto-upload new articles you save in that location, saves literature to the cloud, and that mines metadata to automatically fill in most of the reference data without work on your part. Keep note of the fact that you can use the search function in tools like Mendeley to help you find articles that cover a certain topic, a useful function for last-minute literature review shenanigans. With a plug-in for word processors like Microsoft Word, you can easily cite within the document, revise references, and auto-generate your bibliography as many times as you need to reflect changes in style or order. Most reference managers are user friendly, but please, please, *please* do not spend more than 10–15 minutes downloading a reference manager, installing relevant plug-ins, and orienting yourself to the main features.

We also call your attention to "Activity 4.1: Deciding Which Articles to Read and Which to Skim." Honestly, there is minimal time to read thoroughly at this point. Skim everything. Keep track of three main things: the authors' research questions, the broad method they are using (not the specifics), and the big-ticket primary findings. Record these three pieces of information for each article you skim, and let those guide the way that you see commonalities between articles. If you do

decide to copy-paste anything, ensure that you format it in a different color or another way to show that it is not your text. Because it is difficult to keep track of these details under stress, it is easy to unintentionally plagiarize information. Submitting a less-than-polished draft with an apology and a promise to do better next time is infinitely better than a conversation with the Dean of Academic Affairs over academic integrity.

In terms of the later chapters (7 and 8) – read them. Yes, you are going to lose some valuable time that could be spent writing, but these chapters will help you get that draft on paper. It will take less than an hour to read and will pay in returns well worth the effort. Chapters 9–10? Skim them or save them for later. You can use the self-check in Chapter 10 to provide a to-do list for yourself to your advisor, along with your draft as a way to show that you have plans to keep working on your literature review. After you submit your draft, start reading Chapter 11 on interpreting your advisor's feedback.

For all of you, regardless of what plan you choose, remember that it will all be okay. You will get through this, and this book is intended to help you get through this. If you have procrastinated too much (requiring the "Help!" plans), please get through this and then go back and select another plan another time. For the rest of you, we have designed this book to guide you with exactly what you need and exactly when you need it.

Ready? Go!

1

Why Is Writing So Hard?

Overcoming Barriers to Writing and Making Time to Write

If you are an engineer who enjoys academic writing, and enjoys it all the time, then this book may not be for you. Most engineering students do not feel comfortable with or enjoy writing, typically due to lack of practice and previous unpleasant experiences with writing (e.g. teacher feedback, lab reports, and group-writing projects).

For those of you who have to write your first literature review, you may have some apprehension. This is all normal.

And this book is for you.

We can compare writing to running. If we were tasked with running a 10K (6.4 miles) without training, we could perhaps walk the entire thing, or run some and walk some. Regardless, we would not complete the race quickly, and we would likely be sore for a week after. If we tried to run the entire race, we might get hurt or have to quit, and most definitely we would not enjoy the process. After completing the event, we might not run again for a long time, and if we were to start running again, we would have a lot of apprehension and anxiety about running to overcome. We were not in shape for running, and as such, our running experience would be unpleasant and potentially set us up for failure in future running initiatives.

In the same way, productive writers are conditioned. You do not have to enjoy writing to be an academic writer, you simply have to be productive and get through it. To make it to the end of the "race" (or have completed some academic writing task, such as writing a literature review), we also need to unpack why writing is difficult, and confront these issues either directly or peripherally related to writing that impede the writing process. The reasons that writing is difficult for everyone (even good writers struggle!) stem from the fact that writing is a process that is a cognitive activity, a social activity, and is intrinsically an emotional process

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insofar as our ideas of self-worth and academic identity are often tied up with the composing process. Consider this book as your couch-to-5K training plan to guide you through writing a literature review.

Before we start, this is intended to be an **interactive workbook**. While we help facilitate the process, the work is yours to do. If you systematically work through the activities throughout this text, using the spaces and activities provided to actually *work* (we are serious about the word *workbook* in the title), you will have a solid draft of a literature review ready by the end.

To help with time management, we provide an anticipated time that you should devote to complete each activity, just as we would do with our own students in workshops or in class. This will prevent you from not spending too much time on a given activity and will also give you a guideline for how much time you should be spending doing something so it will be as meaningful as we intend it to be. If you need a little more time or a little less, that is fine, but we wanted to give an estimate to help orient you to the process.

1.1 Writing as a Cognitive, Social, and Affective Activity

The process of writing is often considered a cognitive activity – that is, an action that is occurring within the human mind. There is a great deal of literature that investigates the cognitive processes involved in writing. A writer has to juggle a multitude of things at the same time when writing: technical knowledge, audience, the composing process itself, immediate revision for grammar or spelling, and language issues (especially for non-native speakers). The list goes on and on. Hierarchical process models of writing posit that writers are continually thinking about multiple things at the same time while writing [1, 2]. The mind is amazing: humans can actively recall 7 ± 2 bits or chunks of information in their short-term working memory [3]. At the same time, long-term memory allows writers to open a manuscript and continue to work on it, without rereading and replanning the argument structure. This is what allows us to do immediate edits (spelling, word choice) while continually keeping in mind the overall purpose of the paragraph, the structure of the argument as a whole, and the audience who will likely read the document.

Writing is more than just a cognitive activity though. Writing researchers typically refer to writing as a *sociocognitive* activity, that is, it is both social and cognitive. But how can writing be social, especially since much of writing happens quietly, while a writer sits alone at a computer? Writing is actually highly social because whatever we are writing will hopefully be read by an audience and will impact that audience in the future. Therefore, the system of writing has less to do

with how the writer is writing and is much more oriented toward the reader; this concept is often referred to as writer-centered writing versus reader-centered writing. If a reader misinterprets or does not understand what the writer wrote, it is often not the reader's fault: the burden of clarity lies on the writer. We will discuss this concept and help you envision your audience in Chapter 2.

Lastly, writing is an emotional activity in addition to a sociocognitive activity. Discussing the affective dimension of writing is often uncomfortable for engineers, but anyone who has experienced writer's block (so ... everyone!) resonates with the fact that not being able to get started causes stress. Writer's block causes doubts about the capability to complete the task in general, and perhaps even doubts with respect to whether a career in research is even a good fit. To this end, recent research indicates that engineering graduate students' attitudes about the writing process can influence anticipated career trajectories [4, 5]. While we certainly do not propose that disliking writing is the only reason that engineering students depart from engineering graduate programs, it is conceivable that if a student has had a variety of difficult writing experiences, this in turn causes them to have low writing self-efficacy (similar to confidence). These factors could cause students to leave their graduate programs once they are faced with the task of writing a dissertation or thesis; there is an acronym which describes this scenario – ABD (all but dissertation).

As a way to begin to evaluate some of your own attitudes and postures toward writing, take some time to complete Activity 1.1, which asks you to reflect on your past experiences with writing. It is going to be a little uncomfortable, we know. Begin simply by jotting down some notes: Have you had bad experiences with writing? How does the prospect of having to write make you feel? What is your least favorite part about writing? What is the most enjoyable part?

Activity 1.1 Brainstorm Your Thoughts on Writing

Anticipated Duration: 5–7 minutes

In the space provided, spend some time reflecting on the following questions: How do you feel about writing? Have you had positive experiences with writing? Negative experiences? What made those experiences bad? What writing-related anxiety do you bring into the present writing experience?

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(*Continued*)

Activity 1.1 (Continued)

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Researchers are fascinated with these affective dimensions of writing, especially as they influence behaviors with which writers then employ during the writing process (avoidance is a behavior too). Everyone has issues writing, even good writers. In particular, engineering graduate students struggle with procrastination and perfectionism [4–6], which, as you can imagine, sets writers up for a particularly hard time.

1.2 Time Management, Self-Discipline, and the Writing/Research Timeline

In undergraduate engineering classes, you may have been introduced to technical writing in the form of laboratory reports or memos to sponsors during a design course. Often these documents are written after you have accomplished some milestone or completed the lab activity or the project. However, in these cases, the writing occurs after the project has been completed; it rarely occurs during the project.

Accordingly, many engineers envision writing as the final step toward publishing a paper or completing a final deliverable and simply shrug in accepting writing as a painful process, self-fulfilling the narrative that engineers are not good writers. In reality, the data collection, analysis, and writing processes are often intermeshed. Collecting data is mixed in with data analysis, during which researchers are saddened to realize they need to collect new data. This occurs iteratively, often with a crisis moment toward the end where students realize they need to collect all new data before writing their thesis. Crises of morale, self-confidence, and overall frustration with the research process occur even before the writing itself begins and then often continues throughout.

We hope to convince you to avoid some of this chaos. We challenge you to deliberately integrate your writing within your research paradigm, such that as you are working toward major deliverables, you are also working on writing the parts of your document that you can – even if it involves simply formatting references in a bibliography or reordering paragraphs. Expressing your plans and goals to your advisor may help her or him understand that you are seeking

feedback throughout the process – perhaps after each chapter is written, or perhaps more periodically – such that you can make progress on your deliverable and potentially other written deliverables throughout the research process. Ultimately, while there is still some chaos that will inevitably occur toward the end of a project, embedding the writing may shorten your time to degree completion, or help you achieve more publications during your time in your program.

While we intend this book mainly for graduate students or upper-level undergraduates attempting literature reviews, you may not be in an academic setting. You may be an industry professional writing a literature review for a conference paper or another such context. In these cases, you may not have a supervisor or colleague who monitors the success of the paper or project, but we continue to argue that distributing the writing process throughout the research process is an efficient use of time. As humans, we train our brains to have self-discipline, and, to recall the metaphor likening writing with running, distributing the "training" over time will make the entire writing process more palatable.

1.3 Accountability Is an Essential Part of Writing

Few people have the sufficient self-discipline to sit down and write for a prescribed amount of time each day. Even for people who enjoy writing (or at least do not mind it), writing is often the task that gets delayed to the next day ... week ... or month. You can probably identify times when you procrastinated on writing tasks. If you struggle with the trifecta of procrastination, perfectionism, and low writing self-efficacy – common in engineering graduate students [4] – there are multiple mental barriers that you believe prevents you from writing often or well.

To overcome these very real issues, we present five common strategies to help you develop discipline and accountability in writing.

1.3.1 Shut Up & Write Groups

Structured writing groups provide accountability to dedicate time regularly to writing, leveraging the fact that misery loves company, and that typically on an academic campus there are many people who also have to write. During Shut Up & Write (SU&W) sessions, which ideally are around 90–120 minutes long, a small group of people (typically two to three, no more than five) come together in the same room and simply write. The perception of others' productivity can boost your own self-discipline. Turn off your phone and internet connection to free yourself from email or other distractors. One strategy to boost productivity further is to articulate your goals to your colleagues for each particular session. For example, if you commit to writing an ugly draft of a methods section, then at the end of

the writing time, you can report if you hit your target for writing. If you did not hit your target, you must also explain the reasons why: Did you get distracted and read the news instead of write? Did you get distracted on the methods section, but drafted four pages of the analysis section while also populating your table of contents? Did you encounter an article on your same topic and decide you had to use the quiet time to read the article comprehensively to gain a better sense of where your work and their work differed?

Regardless of whether you hit a target or not in a SU&W session, one way to structure these meetings to achieve maximum productivity involves these six steps:

1) Write down and say aloud your goal for each writing session.
2) Break that goal into several accomplishable steps so you can track progress.
3) Write the next step in the process in the event that if you finish the task you set at the outset, you already know the next item to work on.
4) Set your timer for the desired amount of time (90 minutes is optimum, no longer than 2 hours).
5) At the end of the time, highlight where you are in the document, jot a few notes about where you will pick up next time, discuss with your partners what you accomplished, and then shut down your computer. It is better to end the session with a sense of accomplishment.
6) If you are nearing a deadline on a large project, schedule a full-day SU&W session on a Saturday or over holiday recess. Depending on the needs of the group and the immediacy of the deadline, you may agree to a 6-, 8-, or 10-hour session; in such cases (which can be incredibly productive), plan to set your timer for 60–90 minutes maximum and make sure you regularly get up and walk around, eat snacks, and drink water or coffee.

1.3.2 Accountability Partners

In this strategy, you identify a colleague or friend to be an accountability partner. They do not have to attend the same institution as you or even live in the same time zone. An accountability partner is someone that you can text or email – at any time – to commit to accomplishing a certain goal. The beauty of an accountability partner is they do not need to be paying attention for it to be beneficial – you simply promise to work on some well-defined writing task (for example, the ugly draft of the methods section) and then report back to them; your accountability partner does not need to be an active part of the process.

Bonus points, though, if you find an accountability partner who encourages you to be self-disciplined. The best accountability partners are those who do not mind holding you to your own goals. They might be in your discipline, or perhaps not; ideally, though, accountability partnerships are reciprocal, and you help each

other stay on track. In addition, you may find some helpful peer mentorship occurring along the way, which can help with the isolation and emotional exhaustion that can occur in graduate school or research.

1.3.3 Schedule Your Writing in a Scientific Way

For writers who are strengthening their writing skills, regular training times are essential. Block your writing times off on your calendar and then preserve those times as if they were the most important thing you have to do that day. The trick to scheduling writing time is to place your writing – a highly difficult, cognitive, social, and affective task – in a part of the day when your mind is most *on*. We challenge you to identify when your brain is most optimized for writing. For many people, the morning is a great writing time, cognitively speaking. For some, the very early morning hours (4–7 a.m., for example) are optimal, especially because there are not emails flying about, and typically other members of your household are asleep. Other people are highly productive late at night. Do some experiments. When are you most productive at writing? When you decide, make your writing a regularly scheduled occurrence.

1.3.4 Deliberate and Distributed Practice

Scheduling writing for long periods of time easily leads to fatigue. Begin with 90-minute writing sessions. At the end of the session, save your work and move to another task, checking your daily writing off your list. We find that forcing yourself to write for longer time periods (e.g. blocking off an entire afternoon or entire day for writing) is counterproductive, as you will find your mind and attention wandering away from the task of writing, unless you have gotten into a state of cognitive flow [7]. The exception to this rule is, of course, if you have a deadline to meet.

If you do have deadlines commanding you to write for longer durations, consider alternating longer stretches of writing time with shorter sprints. You may have heard of the pomodoro method for productivity: work 25 minutes, break for 5 minutes, and repeat for several rounds [8]. And by break we mean, try to get up and walk around. Go outside and do some jumping jacks. Do not just check social media or read your favorite blog; the idea of taking a break is to disengage with your electronic device so you can come back to it with a clear head and fresh set of eyes. These strategies are easily applied to writing.

By developing daily writing habits and taking advantage of these strategies, you will build your writing self-discipline and build self-confidence and resiliency. You will also begin to notice that some days are harder than others while other days are more productive and satisfying [9]. Moreover, as you will not be devoting an entire day to writing, you can quickly check your writing time off the list and

move to other tasks. Indeed, this structure to writing helps to distribute the workload leading into high-pressure deadlines. While at a deadline, you will be dedicating a great deal of time to finalizing a written document, the distributed training will kick in and you will be able to make much more progress at the end, and will not be so drained once it is over.

1.3.5 Bribery

When all else fails, bribe yourself. Perhaps this means having your writing session at your favorite coffee shop or saving money in a jar for some purchase. Perhaps it is intangible, such as taking a 20-minute walk around campus after your writing session. Identify what motivates you to write and use it to leverage your productivity using Activity 1.2 to formulate a strategic writing plan.

Activity 1.2 Develop Your Plan for Writing and Accountability

1) What is your goal? Why are you writing a literature review? What is the venue?

_____

_____

_____

2) When will you write?

_____

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_____

3) What are your strategies for writing accountability? Who can you reach out to as an Accountability Partner or to develop a Shut Up & Write group?

_____

_____

_____

4) What happens if you start to fall off your writing plan?

_____

_____

_____

So, what happens if you fall off your writing plan? We have some strategies to get back on track. The first is acknowledging that you diverted from your plan. Do not ignore it – the problem will not go away on its own. Then, schedule a writing period as soon as you identify that you are slipping. Even if means writing for only 15 minutes. Do not get out of the habit. Clear some time, or say no to that extra coffee break, and just write – make yourself feel like you are still on the track. Third, double down on finding accountability partners or a writing group, especially if you are a repeat offender. These accountability partners can encourage you or help you realized that you are not achieving your writing goals. Finally, re-incentivize yourself. What can you be working toward as a reward for yourself? Write yourself notes about it: Stick them on your mirrors, your computer, your refrigerator, or coffeemaker – be single-minded about keeping your eye on the prize.

For all writers, celebrate your victories. It is important to shame yourself only so far as it helps you do better next time – but really, people respond best to positive reinforcement. When you write for some time, or some number of days in a row, praise yourself. Brag on yourself to your accountability partners and then celebrate together as you accomplish goals. These positive feelings help to overcome those inevitable ruts, writer's block, or nasty self-talk.

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2

What Is the Point of a Literature Review, Anyway?!

Stop for a minute and consider how you read literature. Do you read the abstract and the results first? Do you skip to the tables and figures? Perhaps you skim the text from beginning to end and decide if it is worth your time and energy to read in depth (more on reading and skimming strategies in Chapter 4). Regardless of your strategy, you likely do not focus on reading the literature review section first, if at all.

So what is the point of the literature review? Why must you waste time and energy on what is often regarded as the most boring section to read and the most painful to write? A literature review serves at least three simultaneous purposes:

1) It is above all else an argument to justify the purpose for and impact of your research on the discipline at large.
2) It establishes your credibility as a researcher in the field.
3) It allows you to help the reader interpret and appreciate the significance of your technical results.

Ultimately, the benefit to investing time to write a sophisticated, well-executed literature review is that your manuscript will pass through peer review more smoothly, as your reviewers will be well-prepped to understand your argument and the scope of your manuscript. In addition, while a well-written literature review cannot make up for inferior methods or boring results, a poorly written or sloppy literature review casts doubt on the care with which the research is conducted. In the following sections, we discuss each of the purposes of the literature review, further motivating you to write a high-quality one yourself.

So, You Have to Write a Literature Review: A Guided Workbook for Engineers, First Edition.
Catherine G.P. Berdanier and Joshua B. Lenart.

Published 2021 by John Wiley & Sons, Inc.

2.1 The Literature Review Serves as an Argument to Establish a Gap in Prior Research

An effective literature review convinces readers that there is a gap in the body of research at large, a gap that is important enough to fill with your own original contribution. As the author you must present your topic in a compelling way, provide relevant (usually not comprehensive) coverage of the research that has been done in an area, address relevant conversations in the field, discuss specific studies that are of special relevance to the project, and establish gaps in the body of the literature.

Think of the literature review as an inverted triangle, where the broad top of the triangle comprises overarching motivation and background about what is being done in the disciplines, and then each new paragraph continues to focus more explicitly on the details that the author wishes to turn the reader's attention toward (see Figure 2.1).

At the end of the literature review, most research articles have an explicit problem or gap statement, followed by the author's specific research questions and (or) research objectives. (Field- and advisor-dependent, these might be statement as actual questions, or it might be written as a statement of purpose.) Regardless of this format, the questions or objectives must align with the established gap. Think of this alignment as a *hero narrative* wherein you get to play the role of the superhero that exactly fills the gap that you have defined and honed through the literature review.

To prepare writers for common barriers in writing good literature reviews, we address a common misconception before reiterating it in the following chapters when we cover best practices for writing literature reviews. Although we call it a "Literature Review" or "Review of the Literature," our job as writers is **not** to simply report or summarize on what has been done in the literature. It is not enough to simply summarize literature that vaguely aligns with the research topic.

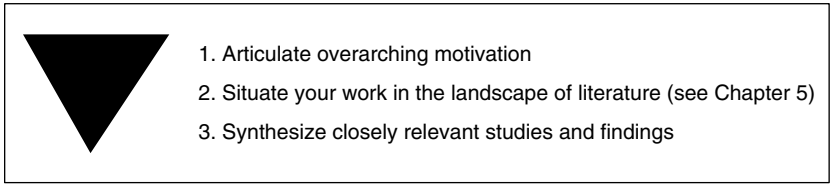

Figure 2.1 The "shape" of the argument of a literature review, envisioned as an inverted triangle or funnel from motivation to specific research questions.

Rather, think of the literature review as a literature *synthesis* because it provides the agency to understand that writers control the arrangement and discussion of the literature in a way that makes sense to them and their advisors. With a literature review, writers synthesize a story by weaving findings from the past literature together in ways that persuade readers into appreciating the research. To lead readers to your argument (and not theirs), you will use guiding phrases, leading words, and signposts to design the story you wish to tell.

2.2 The Literature Review Establishes the Author's Credibility

Pause for a moment and think about reading a paper that has no introduction or literature review. The paper simply launches into methods, results, perhaps a discussion of the findings, and then a conclusion. Unless you were a leading expert in that specific discipline, you would probably feel overwhelmed and frustrated by such an experience. And rightly so! You might wonder if a similar study had been done before, in which case, the point of conducting that research is questionable and suspect. You might wonder how the research contributes to a particular discipline: most research papers seek to solve a tiny piece of a much larger puzzle. Without being oriented to how the research matters, you would likely say "Who cares?!"

These reactions reflect the larger issue that the literature review stealthily establishes credibility of the researcher. In presenting a well-crafted literature review, the reader is subconsciously assured that the researcher understands the overarching conversations in the field and confirms that this research is worth doing and worth reading. Furthermore, a well-designed and careful literature review convinces your reader that the remainder of your study is equally well-crafted and dutifully conducted, while a sloppy literature review plants seeds of doubt within your reader's mind regarding your credibility as a researcher.

The establishment of credibility has a more advanced layer as well. Synthesizing literature in a compelling way is the first step, but the next layer is to carefully consider *who* you are citing and how these researchers relate to each other. If you cite certain groups, you are inherently aligning with their positions and approaches to that scientific field of interest. Similarly, *not citing* certain groups can act as an equally strong statement. In fields that are rapidly developing, or those that have strong conversations occurring between equally respected research groups, be sure that you can interpret how these various groups relate to one another before you cite them together or fail to cite especially impactful papers.

In a passage titled the "Unending Conversation," rhetorical theorist Kenneth Burke compares the process of learning to publish with what you might do if you attend a party and try to join an ongoing conversation [1]. First, you would listen in and try to decipher what people are talking about. When you are ready to join in the conversation, you would need to build off other people's ideas to then voice your own viewpoint. You would not simply report on what people had said, and you would not necessarily support everyone's point of view; instead, you would build on one side of the argument while acknowledging that others hold other perspectives. You might make your statement based on other conversations or experiences you have had in the past. Most importantly, you would not repeat other people's ideas and act like they were your ideas without acknowledging that they had held that opinion first – that is a good way to lose friends, and if you are new to the group, a good way to alienate yourself.

Kenneth Burke's "Unending Conversation" Metaphor

Imagine that you enter a parlor. You come late. When you arrive, others have long preceded you, and they are engaged in a heated discussion, a discussion too heated for them to pause and tell you exactly what it is about. In fact, the discussion had already begun long before any of them got there, so that no one present is qualified to retrace for you all the steps that had gone before. You listen for a while, until you decide that you have caught the tenor of the argument; then you put in your oar. Someone answers; you answer him; another comes to your defense; another aligns himself against you, to either the embarrassment or gratification of your opponent, depending upon the quality of your ally's assistance. However, the discussion is interminable. The hour grows late, you must depart. And you do depart, with the discussion still vigorously in progress.

Burke [1]

Writing a literature review is like having a conversation at a party, except that it is a party about knowledge, and the specific conversation groups deal with to discuss the problem or approach. This type of conversation is not verbal but written. It is in the way that writers interact on the page. How people listen to this conversation is by knowing the historical literature and being current of the most recent literature. The way people engage in the conversation is by writing their additions up and publishing them while showing how they fit into the wider conversation, which moves at a near-glacial pace compared to face-to-face conversations. Nevertheless, the mechanics of these types of conversation share the same features.

This aspect of joining a disciplinary community comes with time and persistence. One way to jump start your familiarity with primary researchers in your field begins with attending conferences and becoming a member of a professional society that publishes in your area. By attending conferences and comparing discussions at such events with the literature that is published in the proceedings at the conclusion of the conference, you will start to recognize and better understand the nuances in the conversations that are occurring in journals. Be aware, the party moves faster at conferences, too, so it is easier to keep up with the most recent work before it is published to journal. As a bonus, attending academic conferences allows you to have real-time conversations about the science with some of the brightest minds in the field.

2.3 The Literature Review Prepares Readers to Interpret and Appreciate Your Findings

Recall the hypothetical literature-less paper you envisioned in the previous section. Imagine you continue to read through the methods and the results, which the authors likely claim are quite important. In this imaginary scenario, the authors are essentially asking you to take their word that their work is valid and reliable. However, without a literature synthesis, the authors must work doubly hard to convince you that their work is important and valuable.

This scenario gets to the third main function of the literature review: if the effective synthesis of literature at the beginning of an article aligns directly with the research questions and methods, then the reader is inherently better prepared to value and find novelty in the results. Even before reaching the discussion portions of the paper, readers remember the gaps that you established in the literature review and will become increasingly convinced of the value of the work. Then, when you interpret the results and relate them to broader disciplinary conversations in the discussion section, your readers become even more impressed. The thought logic here is simple: make it easy for readers to appreciate you. A well-aligned literature review allows you to spoon-feed the impact of your results to the review panel and future fan club members.

2.4 Envisioning Your Audience

Writers should always hold the needs and expectations of their anticipated audience in their minds. Who is your audience? What do they look like? What do they do for a living? What toppings do they like on their pizza (just kidding!)? What

biases or expectations do they bring with them to work and into their research? What questions will they likely ask if you told them about your project? What is their native language? In what language do they expect to see your work appear?

Different audiences have different needs. For example, in this book, we aimed for concise language paired with an informal, conversational tone and pace. We predicted that our audience have not had positive experiences with writing literature reviews, or that this may be the first time that they are writing a literature review. We anticipate that engineers have not had a great deal of formal writing instruction. Therefore, keeping OUR intended audience in mind, our goal is to make writing a literature review more approachable for YOU. This view influences our decisions of how much and what types of examples we present in subsequent chapters. This workbook does not use technical jargon to posture for our fellow scholars – they are not our audience. You are.

For literature reviews, keeping audience in mind is critical. If you are a graduate student, perhaps you are tasked with writing a literature review about your thesis or dissertation topic, or are simply supposed to write a literature review to develop a better understanding of the field before you dive into research. If you are an undergraduate student, perhaps you are writing a literature review as part of a report or final paper for your undergraduate research experience. If you are an industry professional, perhaps you are writing a literature review to achieve a deep understanding of the state of the art in a field or technology. All these literature reviews are part of the same genre, and because you are engaging with scholarly literature during your review, you should assume that the audience for your literature review is similarly from an academic or scholarly context.

Imagining an audience is particularly difficult for internal reports, or for literature reviews that will likely not be read beyond getting rubberstamped for an undergraduate thesis, a report, or an internal document. However, the expectation of the people who are tasking you with writing a literature review is that your tone and language will follow a scholarly tone. You should write your literature review as if an entire disciplinary community will be reading it, not just your advisor, supervisor, or teacher. Imagining a large audience of scholars, rather than writing to an individual, is quite important to achieving the tone, argument structure, and language patterns characteristic of a literature review.

2.5 Deliberate Language Choices Support the Functions of the Literature Review

The language that you use and the ways that you refer to other researchers in a literature synthesis is important in establishing a research gap, developing credibility, and helping readers to appreciate your results. We will discuss tricks to

connect ideas in Chapter 5, such as the use of linking words and using the language inside sentences to tie ideas together. In the meantime, as you begin gathering literature (Chapter 3) and skimming or reading it (Chapter 4), try to read analytically as well as for content. When reading analytically, you are interested in *how* the argument is put together rather than the topic itself. We challenge you to consider how other authors create an inverted triangle in their arrangement of a literature synthesis (Figure 2.1), how they explicitly establish the gap in the literature, and how they scope their research questions to directly align with their research findings.

However, to have articles to read either for content or for function, we must get into the literature. That is the next step. Turn the page.

Reference

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3

Gathering and Storing Literature

In this chapter, you will start collecting literature. There are several activities that will require you to be on a computer in preparation to collect literature. In preparation for the activities, you need to understand the different types of journals and other publications. While the specific journal or conference venues will vary by subdiscipline of engineering, the same patterns hold regarding the value of different tiers of publications.

3.1 What to Cite? The Difference Between Types of Academic Publications

Academic journals are classified by tier, which reflects the quality and competitiveness to be published in a particular journal. You are likely familiar with some of the best-known journals, such as *Nature*, but each discipline and subdiscipline has its own top-tier journals. Perhaps you are familiar with the ways in which people have tried to configure indices of quality for various journals (e.g. Impact Factor, Scientific Journal Ranking, and the H-index); however, every subdiscipline has journals that are difficult to get into and publish the best work, even if they are not as well known in other subdisciplines. You can easily find lists of journals and their rankings online for your discipline. In the space provided for Activity 3.1, conduct a quick search for journals in your subdiscipline and make a list of five of the top journals for your research area. You can also ask your advisor or more experienced grad students in your research group.

So, You Have to Write a Literature Review: A Guided Workbook for Engineers, First Edition.
Catherine G.P. Berdanier and Joshua B. Lenart.

Published 2021 by John Wiley & Sons, Inc.

Activity 3.1 Generate a List of Relevant Journals

Anticipated Duration: 15 minutes

Use the Internet or your research group to determine some of the top journals in your research area. Write them down in the spaces below. There may be particular journals that are known for one area or topic: Use the "Notes" space to keep track of these items.

Journal Notes:

1) _____

2) _____

3) _____

4) _____

5) _____

While research published in a top-tier journal carries the most merit and prestige, Tier 2 journals – those not as prestigious – are still perfectly fine to publish in and to cite in your literature review. Tier 1 and 2 journals share some characteristics, the most important of which is the fact that all research in these journals undergoes a clear and thorough peer-review process.

On a journal's website, you should see a clear list of editors, associate editors, and board members, and these should be well-known members of the discipline and are generally from universities with strong reputations. In your literature review, you should rely mostly on peer-reviewed journal articles to represent peer-reviewed and documented findings from your discipline. Even if a journal is not as highly ranked, it may still be the best venue for a particular study and is valid to cite.

Conference publications also have different ranks, indicating that some work published to a conference is of higher quality than others. While your literature review should cite mostly journal articles, the process of getting work published can be lengthy, and sometimes the most recent work is published at the conference level before initiating a journal publication. Therefore, if you want to cite conference papers in your literature review, and it is an accepted practice in your discipline, then perform the same type of quality assessment as you would for journals. Identify the top conferences in your subdiscipline and cite only those that have undergone the peer-review processes. Some conferences only have abstracts affiliated with them, and these are not typically good to use in a literature review because there is no way to identify the complete research narrative.

There may be instances where other types of publications are necessary. The most common are national reports or industry briefs that discuss the state of the field. National reports from the National Science Foundation or the National Academies, for example, often highlight pressing issues of national research importance. Industry reports may have overarching statistics that motivate focus on one context or issue. In general, these types of publications are most useful in the parts of your literature review that motivate the context for your research.

3.2 What NOT to Cite: Types of Documents to Avoid Citing

There are several publication types to avoid including in academic literature reviews. While there may be exceptions, as you are learning to write literature reviews, consider these guidelines for what not to cite.

Popular Science Magazine Articles. Avoid popular science and engineering articles that are summaries of existing research, such as articles in *Popular Mechanics*. This is not to say there is anything wrong with magazines or their accuracy, but the work is simply not the original, scholarly, peer-reviewed work. However, if you think the topic merits a place in your literature review, locate the original scholarly sources for data and cite those instead. But, as an overarching best practice, do not cite pop-science magazine articles or web articles in your literature review. The same advice holds for press releases on recent technologies. One underlying litmus test for questions along the lines of "Can I cite this?" is the answer to the question, "Did the researcher who conducted the research write the report?" If the answer is *yes*, you are probably okay to cite it in your literature review. If the answer is *no*, then it is best to find alternative sources. If a topic is popular enough that there is a pop-science article written about it, we guarantee there is available peer-reviewed scholarship to support that science.

Websites. Most websites are not suitable for citing in scholarly publications. If you find an article reporting something, locate the original scholarly source and read it yourself. As a rule, do not cite websites. Even reports that come from government or industry will likely have a PDF version that you should cite from instead.

Wikipedia and Other Encyclopedia-type Sites and Books. Encyclopedias and modern encyclopedia sites, such as Wikipedia, are a great way for students to orient themselves as they are learning about a field or to gain basic understanding of a topic. However, they are *never* appropriate to cite in a literature review, whether it be for a class or for publication. As with the others, the information found in these sites can be found in other primary sources that should be cited instead. Again, locate the original source. Never cite Wikipedia.

Books and Textbooks. Books fall into two categories that are more along a spectrum at the graduate level. We characterize textbooks as foundational teaching texts that you might be assigned as part of a class to learn thermodynamics or fluid mechanics. These have foundational equations and principles in them, intended for teaching. You may indeed be using these texts as you are conducting research, but rarely will you cite the textbook because the material is so well established (often for decades or centuries) and it can stand alone. Your literature review will be reviewing relevant research, so a textbook is not useful for most literature reviews.

However, there are books related to sophisticated methods or scientific advances that are written by experts in a particular area. Many of these serve as seminal works in an area. These are generally not employed as textbooks in undergraduate-level courses, although they may be used in graduate-level classes. At times, it would be appropriate to cite these; however, in science and engineering (unlike the social sciences and humanities), books are not commonly cited in literature reviews. Again – all the findings would have been published first in peer-reviewed, scholarly publications before ending up in a book.

Open-Access Publications, Publishing Ethics, and Predatory Journals

Current conversations in academic publishing and ethics focus on the issue of open-access publications. Most reputable academic journals operate behind paywalls, so that to access the articles, readers either need to be part of an institution that has paid for a subscription to the journal or individually pay to read the article. Some critics argue that this practice is unethical, and that science should be easily accessible to all people, including all researchers and students at small universities – not just the large, resource-wealthy universities. This issue is particularly problematic for researchers in developing countries. Therefore, today, many traditional journals have the option for authors to pay a little more to publish their work with open-access privileges. Other journals have emerged that are online and open-access. Some online open-access journals are reputable in terms of quality, but as with anything else, the availability of online web space opens opportunities for predatory journals.

Be aware of predatory journals. You may receive emails that invite you to submit your work to a journal, based on a recent conference paper that you may have helped author. Just like spam email, there are typically indicators that something is suspicious about these offers. First, top-tier journals do not typically email scholars to publish work. These suspicious emails may also include typos, inconsistent fonts or colors, or broken links. Most importantly, these predatory journals will offer a fast turnaround time for publication, because they do not follow a peer-review process. With a little research, you can easily identify these impostor journals.

3.3 Searching for Literature

Consider quality control standards as you search for literature. For every article you find, go through your mental checklist and ensure it is from a reputable journal and that high-quality work has been conducted. There are a variety of methods for searching for literature. One of the most convenient is Google Scholar, which offers access to many publications and is a good first step to surveying the literature. While Google Scholar is efficient, your institutional library likely has access to a wider breadth of journals and manuscripts and will be able to request resources through interlibrary loan. These services differ by university, so contact your university librarians for a description of resources. University librarians are highly skilled researchers who can help you to collect literature and gather sufficient resources to conduct your review. Working in concert with a research library in your subject area will help you leverage your institutional resources and learn to search more efficiently using Boolean operators and advanced search options.

After you identify several relevant pieces of scholarship, mine the references sections to compile a deep collection of relevant literature. Regardless of how you find your literature, keep lists of your search terminology so you can be efficient without duplicating efforts. Your university librarians can also help you to generate appropriate search terminology strategies.

3.4 Saving and Storing Your Literature

We cannot emphasize enough the importance of a systematic and organized approach to saving and storing your literature. The advent of the digital age made scholarly articles easily downloadable, but without a systematic naming convention and digital filing system, the articles you identify are not useful to you. In the following sections, we recommend several things to consider and offer a few useful methods for storing your literature. At the end of this section, we will ask you to define a naming convention and storage plan before moving forward in the book. If you carefully plan this strategy near the beginning of your scholarly career (i.e. NOW), you will remove a great deal of uncertainty and frustration for years to come.

Develop a Naming Convention. When you download any article and save it, decide on a way to save it in a way that is most useful to you (i.e. you will be able to find it and know which article it is in the future). Therefore, do not simply save the document file with its original name. PDFs are rarely named in a straightforward convention and often a mix of letters and numbers – not at all useful to a user. In determining a naming convention, consider the following information to help you arrive at an effective naming convention strategy.

- **Files are stored in alphabetical and numerical order.** Consider the order in which your documents will appear in your files, if you would choose one particular naming convention over another. As examples: If you choose to save articles using the first author's last name (e.g. Adams, Murphy, and Zdenek), they will appear in the alphabetical order. If you choose to save articles by their titles, those too will appear in the alphabetical order. In contrast, numbers will appear sequentially ahead of alphabetic filenames. How do you want to see your literature? What will be most useful to you?
- **Filenames should be pragmatic and useful.** What information is most necessary for you to remember what each article contains? Is author name something that is useful? Is the title important or are a couple of keywords more useful to you? Is the name of the journal something you would like to see in order to effectively find the article you are remembering or trying to cite? You get to pick this information, so pick information that is relevant or useful to YOU.
- **Some advisors have preferred filename styles for shared literature.** Your advisor may have a preferred style for the research team. If the advisor's style does not match yours, we recommend that store your literature in a way that makes most sense to you, and then re-save it for your research team in the alternative style. Ultimately, since you are the one writing the literature review, a little extra legwork will help you more quickly and easily access the literature you need to find.

Considering these elements, one convention that can be quite useful is storing literature with the year of publication first, so that it is easy to see how recent journal articles are, then following with the first author's last name, and then the title of the journal article. Because article titles should be concise and representative of the paper's content, these are often effective pieces of information for recall. You can also choose the case (capitalization) to emphasize certain parts – one method is the data, author's last name in caps, and the article title in sentence case (e.g. 2016 BERDANIER Aligning engineering education with disciplinary expectations – A strategic blueprint for doctoral competency assessment).

The advantages to this method are (at least) threefold. First, in a digital folder, the literature will all be listed from oldest to most recent and is easily reversed using the file view settings. Second, the last name of the first author makes it is easy to visualize who the primary scholars are, making it easier to recall which of a particular author's work is which. Third, you can easily see where you are missing years' worth of research if there are significant gaps in the literature timeline that is established upon visual inspection of your virtual documents.

File Organization Schemas. Now that you have decided on a naming convention, it is important to strategize how you intend to organize the literature within folders and subfolders. As you develop as a scholar, you will start to work on more than one project, which may be somewhat related – or not at all related – to other projects. While some literature might be useful to multiple projects, it very well could be project-specific. Your filing system needs to be scalable and should support use on multiple computers (e.g. your computer at home, at the lab, and personal laptops). If you have, or could have, multiple computers that you spend time writing on, it is ineffective to have a folder stored on a single computer desktop that is named "Literature." We recommend having one primary "Literature" folder, potentially stored on a backed-up, cloud-based solution, in which you store all your literature. If you store literature to your independent computers, have a system for moving those files periodically to the host literature folder. Perhaps this could be done at the end of each semester, or some other regular interval.

There is no one way to organize literature, but there are a couple of effective methods that have proven useful. One way is to organize literature by topic, so that you can easily catalogue and sort your literature and find it later when you need it for another related project. Another way is to sort literature by project. For example, if you are working on a particular paper, storing all the literature that you are finding specifically for that paper or project can be beneficial while you are working on it. You can also use a hybrid of these approaches: storing literature by topic, and then as you are gathering new literature in support of specific manuscripts, creating files to store literature for the particular paper. Then, when the project or paper is complete, you can sort the project-specific literature into your topical files, creating new subfolders with different topics as necessary.

This method may seem like a lot of work that is not technically "writing" – we know. However, we want you to consider helping out your future self by anticipating that a little work on the front end will pay off in lower levels of frustration later. Now, it is your turn to make some decisions about your file naming convention by answering the questions in Activity 3.2.

Activity 3.2 Determine a Naming Convention for Your Literature

Anticipated Duration: 10 minutes

Answer the following questions. If you need to consult another person (e.g. your advisor), do not procrastinate. You can also fill these out for your own preferences and then follow-up with your advisor at a different time.

(*Continued*)

Activity 3.2 (Continued)

1) How do you want your literature arranged when you open your digital file folder?

_____

_____

2) What information is most necessary for you to remember about each article?

_____

_____

3) Does your advisor have a preferred file naming convention?

_____

_____

4) Is there information that you would prefer to have in a different case (e.g. all caps) to separate it from other pieces of information?

_____

_____

5) What file naming convention best fits the answers to the above questions?

_____

_____

6) What benefits does your chosen convention offer to you with respect to how you remember information?

_____

_____

7) Are there any downsides to this convention? If so, tweak your convention to mitigate these if possible.

_____

_____

8) How will you organize your literature in digital folders?

_____

_____

3.5 Reference Managers

We recommend you use a reference manager to help organize your literature. While we anticipate that new reference managers will continue to emerge that offer new and improved services, managers like Mendeley, Zotero, and Endnote are currently the most popular. Some, like Mendeley and Zotero, are free, and some have the capabilities to share literature among teams of researchers. All reference managers, though, are most useful in their capabilities to store literature online and to help you cite literature automatically while you are writing. In our opinion, the most useful attribute of reference managers is the ability to automatically format in-text references and end-of-text reference sections in a wide variety of preprogrammed styles, and the ability to program your own reference style. If you continue to add references during the editing process, your reference list – with the help of the reference manager – will automatically update. For anyone who has had the misfortune of renumbering a reference list at the end of a project, a reference manager will become your new best friend.

Selecting a reference manager is a personal choice. You might ask your research team or advisor if they have a preferred reference manager or a shared management system, or if your university has a subscription to any reference managers. Research your reference manager choices and select one that meets your needs. Take some time now to complete Activity 3.3, which is to create an account with a reference manager and prepare to employ it as you write.

Activity 3.3 Select a Reference Manager

Anticipated Duration: 30–45 minutes

Take some time to decide on a reference manager. Ask your research group what they use. If your group subscribes to one common system, we highly recommend aligning with that. If your group does not use a paid service, spend some time researching free cloud-based reference managers and register for one that you will use in your scholarly career.

3.6 Your Turn: Collecting Literature

Now you can begin to collect your literature. To effectively synthesize the body of knowledge related to a particular topic, we recommend collecting at least 50 closely related pieces of literature. You may not cite all of them in your literature

review (you may, alternatively, refer to more than this), but this number is an appropriate starting point for someone to effectively engage with and synthesize a particular research space.

With research analytics and search engine optimization in databases like Scopus, Web of Science, and Engineering Village, engaging with literature in some sense has never been easier. Nor has it ever been more difficult. On the one hand, until you begin to really understand how individual researchers and research cohorts relate to one another, you have probably not yet spent enough time engaging and reviewing sources for your literature synthesis, so you will need to collect a lot of literature through the process. At the same time, during the initial stages of compiling literature, database analytics tend to provide too much irrelevant information. Because of the sheer volume of information that is available in research databases, students are often frustrated, distracted, and ultimately spend a lot of time trying to identify the relevant literature (without much success) instead of actually reviewing the appropriate literature.

To avoid this repetitive cycle, start small and locally. Begin by reading literature that was produced by your advisor or other faculty doing similar research in your department. If you have trouble accessing an article online, use library resources, or, email the researcher and ask them to send you the PDF file. Pay attention to the reference sections and then look into those authors and articles as a way to expand your research concentrically and systematically as opposed to trying to search the entire internet at once.

Based on the couple of articles you read of your advisor's work, you are now empowered to begin generating search terms to create a wider body of literature. Do not do this all at once – that is not an effective method for tackling any big task. Instead, let us guide you through this process. First, we just want you to conduct a literature search with the keywords that are most relevant to your particular topic. Decide on a few keywords or phrases that you think will generate relevant hits in Google Scholar or literature databases. Are there particular scholars or research groups that are main players in this space? Activity 3.4 asks you to document these search terms.

Activity 3.4 Articulate Keywords and Main Players

Anticipated Duration: 20 minutes

1) What keywords might I use to begin to search databases for literature related to my project? (Consider both topics and methodological approaches.)

_____

_____

Activity 3.4 (Continued)

2) Am I aware of any "main players" or primary scholars who research in this space? (Your advisor may be one of these main players, and she or he, or a more experienced grad student in your group, can recommend others.)

_____

_____

_____

We will now guide you through your first literature-gathering adventure in Activity 3.5. This is the first of our longer activities. As a note, if you cannot access an article without paying a fee, *find alternate ways to access the article*. Many universities have robust interlibrary loan resources, or you are free to email the corresponding author and ask them to send you a preprint of the article. Consulting with a research librarian who specializes in your subject matter is one of the best ways to find articles without paying out of pocket.

Activity 3.5 Generate and Save Your First Batch of Literature

Anticipated Duration: 60–90 minutes

Search the keyword terms and/or researchers you have generated above. Open as many articles as you deem relevant – this is not the time to read them, though. Resist the temptation to read! If the title seems to be relevant to your particular literature review, open it, and then continue to find more literature. Do not save them all right away – it is much more time-effective to open a bunch of literature, do a cursory glance of applicability, and save the ones that you anticipate will be useful. Continue this until you are (i) tired of opening literature, (ii) running out of time, or (iii) you are worried you have too many tabs open such that your computer might crash. As a point of reference, at the end of this activity, we would like you to have collected at least 20 articles that appear closely related to your project.

- Now is the time to begin giving a cursory look at quality of the articles and proceed to saving them. First, decide where you are going to save all this literature – create new subfolders as necessary. Then, one article at a time, quickly skim the abstract. By skimming, take no more than 60 seconds to scan for keywords that grab your attention.

(*Continued*)

Activity 3.5 (Continued)

- If the article is somehow not at all related to your search terms, close that article without saving it. However, if you judge the article to be relevant to your project, proceed to save the article in the naming convention you already selected.

- DO NOT leave your computer until all the articles you opened have either been saved in the appropriate naming convention or closed because they are not relevant. We implore you – from our own personal experience – not to leave windows with unsaved literature open on your computer. Without fail, your computer will decide to restart, or you will accidentally close windows and lose your hard work. Do not let this happen to you.

Continue this activity until you have found and saved 20 articles that are relevant to your research project. At this point, you have saved the articles, but have not read them. This is all okay; it is where you should be at this point. Embrace the tension and let the system work.

3.7 But How Many References Do I Need in My Literature Review?!

The most common question we get from our students is "How many references do I need in my literature review?" or "How long does this need to be?" Much to our students' chagrin, our answers are always, "It depends" and "When you have effectively established the gap in the literature." The number of references that is appropriate depends on the venue in which you are publishing: conference papers in general have fewer references than journal papers, which have potentially fewer references than grant proposals ... though that, too, depends on the venue. The best way to answer your own question is to use Activity 3.6 to do a quick analysis of manuscripts like the one you intend to write (e.g. thesis, articles from your intended journal).

Activity 3.6 But Professor, How Many References Do I Have to Have?

Anticipated Duration: 45 minutes

Open about 10 articles that mimic the venue for which you are writing. As examples, if you are intending to publish in a certain journal, open articles published in that journal (you can collect more if needed). If you are writing a

Activity 3.6 (Continued)

master's thesis or dissertation, look at past theses or dissertations from your research group. If you cannot find direct examples from the venue you are targeting, think about similar venues (e.g. conferences or journal articles with similar audiences).

1) Use the space below to document the number of references in each document in total, references employed in the literature review alone, and the "density" of literature in the lit review section (or chapter, if you are doing a thesis or dissertation). Follow the instructions in the table to calculate these values. Of course, these numbers depend on the format of the document, such as the number of columns and the font size. Do not worry about perfection; you are looking for general trends.
2) After you have collected this information for about 10 articles, average each column. These numbers should give you a normative range that you can aim for, answering your own questions to, "How many references should I have?" and "How long should this be?"

Sample article	Column A: Total no. of references in article	Column B: No. of references in intro and literature review	Column C: Length of intro + lit review (round to nearest ¼ of page)
	Average number of references per article for this venue. Sum rows in Column A and divide by the number of articles surveyed (here: 10 articles)	**Average number of references in a typical intro + LR for this type of venue.** Sum rows in Column B and divide by the number of articles surveyed (here: 10 articles)	**Average page length of the intro + LR in this type of venue.** Sum rows in Column C and divide by the number of articles surveyed (here: 10 articles)

Let us reflect briefly on these data. Likely, you will note the range in number of references employed in total (Column A), with the bulk of the literature employed in the introduction and literature review sections (Column B) and the variation in length of the literature review (Column C). Although they are ranges, notice that the fraction of the article length devoted to the intro and literature review is approximately the same (typically 10–15% of the article length) and the density of the literature in the review section is rather consistent. These are guidelines you should apply to your document.

This does not mean you are done with your literature review once you reach this page limit; rather, when your literature review is edited, it should mimic the general expectations for these parameters for the venue. Keep in mind also that different venues will have different ranges, depending on audience, conventions, and constraints such as page limits.

Overall, Activity 3.6 should have confirmed that the literature review can vary based on the needs of the argument, but also that articles in the same venue typically conform to similar unstated expectations. Activity 3.6 also calls attention to the pragmatic nature of the scoping of the literature review. In other words, the literature review is done when it is done; it is done once it effectively synthesizes the existing literature and establishes a research gap. We work toward accomplishing these ends through the next chapters. In Chapter 4, we discuss strategies for reading academic literature before organizing and synthesizing literature in Chapters 5 and 6.

4

Reading Strategies and Remembering What You Read

By this point, you have accomplished a great deal of preparatory work that will enable you to hit the ground running on your literature review. You have decided on naming conventions, a filing system, and have collected at least 20 articles that are relevant to the body of knowledge you intend to synthesize through your literature review.

So, what is next? Well, it is the dirty work – getting into the literature.

The cardinal rule of reading literature is that you should not actually *read* literature – at least not in the traditional sense. When students envision reading literature, they often picture themselves sitting on the couch, document or tablet in hand, and reading the textual linearly, from title to acknowledgements. This is an ineffective reading strategy, especially if the article turns out to be either peripherally related to your topic or not even useful at all.

We propose an alternative and more efficient method for reading and skimming literature and give you the opportunity to practice. If you are familiar with the nonlinearity of skimming and reading scholarly literature, feel free to skip to Chapter 5. However, you may find a refresher useful.

4.1 Deciding Whether to Skim or Read

Learning to skim literature is one of the most valuable skills in your arsenal. Determining whether skimming suffices, or whether you should dedicate the energy to reading the entire text, will ensure that your time and attention is used effectively. Consider these general guidelines:

- Read the article fully if the abstract and keywords are closely aligned with your method or topic, or if the research group conducting the research is well known in your field.

So, You Have to Write a Literature Review: A Guided Workbook for Engineers, First Edition.
Catherine G.P. Berdanier and Joshua B. Lenart.

Published 2021 by John Wiley & Sons, Inc.

- Skim the article if the abstract and keywords are connected to your literature, if the researcher is not as well established, or if it is a report related to the motivation for your work. You can always go back and read more in depth if it turns out the work is highly relevant to you.
- Skip the article if the abstract and keywords are not related to your topic, or if you quickly realize that although the abstract seemed useful to your ends, the paper itself really was not (it is okay.)

If it helps you to decide, here is a decision flowchart (Figure 4.1):

Pause here for a moment. Activity 4.1 is your chance to practice this method using the 20 articles you collected in Chapter 3.

Activity 4.1 Decide Which Articles to Read and Which to Skim

Anticipated Duration: 1 hour

In the digital folder in which you have saved your articles, create two new subfolders, entitled "read" and "skim."

1) One article at a time, open your documents and read the abstract. Spend a couple minutes with the abstract, and then proceed through the decision-making flow chart to decide whether to skim or read the article.
2) If you decide to skim, move it into your "skim" folder. If you decide it is worth your time to read it, move the file into the "read" folder. You are basing all these decisions on a close reading of the abstract and the authors, and nothing more.
3) Sort all 20 (or however many articles you collected in Chapter 3) into these folders. If you read an abstract and you realize the article is somehow not at all useful to you, then you can delete the file from your folder. However, your cursory glance of quality when you saved the articles should have culled most of the fruitless literature from your files.

4.2 What Are You Focusing On?

When you are reading or skimming, imagine that you are putting on different pairs of figurative glasses. You might pretend that you are putting on your

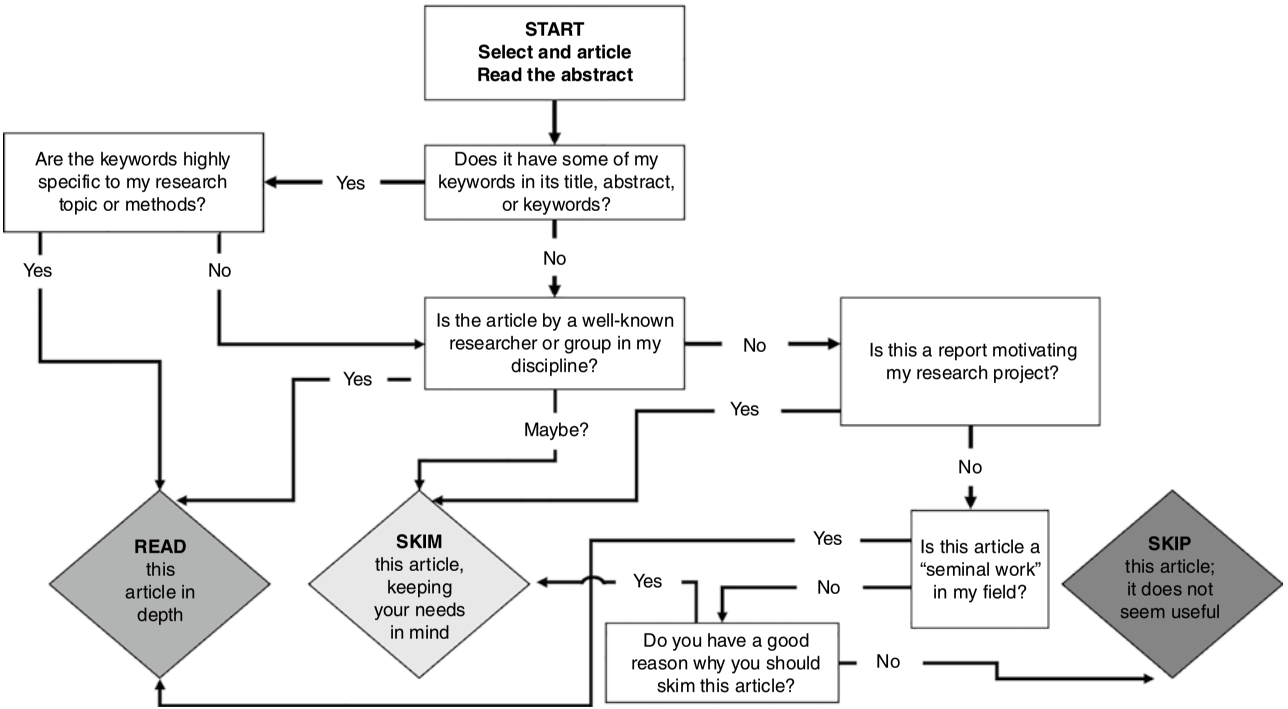

Figure 4.1 Decision flowchart to help you decide when to skim, read, or skip articles.

"methods" glasses that focus your attention on methods – either different methods people have used to study the same phenomena you are investigating, or people who have used the same method to study either similar or different phenomena. Either way, your "methods lens" filters all the other pieces of literature, focusing your attention and efforts on the author's methods and results stemming from that choice of research methods. Alternatively, you could put on your "topic" glasses that filter other information and strictly are looking to establish which research groups are investigating your particular topic or phenomena. This is a good strategy to begin to learn who the primary researchers are in a particular area. Articles can be useful for a variety of things, and they may not serve to be useful in both the topic and methods category. In fact, it is a good thing if you do not find many articles that are closely related or useful to your project through many of your lenses because, ultimately, through your research, you should be trying to establish a gap in the literature that you intend to meet through your particular research. At the beginning of a research project or a literature review, it is helpful to hold both of these focuses in your mind as you summarize an article.

4.3 Effective Methods for Skimming Literature

At this point, you have sorted your literature into the "skim" folder and the "read" folder. You have read the abstracts of all this literature and should have a good understanding of the types of literature you have collected. When you skim literature, it is most useful to skip around to different parts of the article, holding in your mind what you are seeking from the article. Generally, when we write in engineering, we want to know what people are working on similar topics as us and what they have found, or what methods people are using or developing to study phenomena. Most engineering research today, even fundamental research, is highly interdisciplinary and methods are borrowed across disciplines in science, engineering, computing, physics, and even the social sciences and humanities. Therefore, keep in mind what you are reading each article for, since you may be employing articles from unfamiliar disciplines or subdisciplines. As a result, it does not matter if you can understand all the details, if you are getting what you need from that article. Skimming will help with that.

When you skim, look for the information that is most important to you. Scholarly literature is relatively predictable in terms of how information is organized within a text. Additionally, the reader can take advantage of the fact that the first and last sentences of each paragraph typically hold the most powerful and most important textual information, and the figures presented in the paper usually summarize the

most important results of the research. The abstract and conclusion are also immensely valuable for proving a succinct summary of the article.

Below are alternative methods to reading and skimming based on different uses of literature. Use this first strategy if you do not have an immediate objective in mind for how to read the literature:

1) Title and authors
2) Abstract
3) Research objective or research questions (typically the end of the literature review/background section)
4) Figures/Results – what did they find?
5) Conclusions
6) Other sections of interest (e.g. Methods, Discussion) as you see fit to answer any questions raised for you

However, if the article covers a topic or phenomenon of interest to you, the next strategy helps you focus on that phenomenon:

1) Title and authors
2) Abstract
3) Research objective or research questions (typically the end of the literature review/background section)
4) Note context-dependent specifics: experimental setup, etc.
5) Note the broad methods used for the research
6) Figures/Results – what did they find?
7) Conclusions
8) Other sections of interest as you see fit to answer any questions raised for you

Alternatively, use this strategy to focus more on the research methods:

1) Title and authors
2) Abstract
3) Research objective/research questions
4) Note context-dependent specifics: experimental setup, etc.
5) Skim methods section from top to bottom
6) Note broad results, focusing on limitations and how methods influence findings
7) Results and Conclusions
8) Other sections of interest as you see fit to answer any questions raised for you

The time it takes to skim a piece of literature depends on its importance to your needs. Typically, plan 5–20 minutes skimming an article while making note of important passages. Again, focus on those first and last sentences of each paragraph – these often emphasize the main takeaways.

4.4 Reading Scholarly Literature

Of course, reading and skimming is a spectrum – you can skim most parts of an article, but then do a close read of sections that matter to you (e.g. the methods or results section). You will also develop your own strategy for skimming literature and may have a unique and preferred order of operations for the process. In reading scholarly literature, you will likely follow a similar order to the one that you will employ when skimming, except that instead of letting your eyes focus on the first and last sentences, ignoring many of the small details and focusing on the topics for which you are reading the article in the first place, you will spend time absorbing the details.

In doing a close read, it is important to stay actively engaged when reading. We have all had experiences where we sit down to read an article, and we find that we have read a paragraph or page without comprehending or retaining that information. To combat this tendency, here are some strategies for reading.

1) Consider your purpose. Why are you reading this article? If you are reading to understand how the authors apply a method, keep that in mind as you are reading the methods and results sections.
2) Print the articles you intend to fully read. Literature indicates that humans encode information they read in print differently than in digital form, suggesting that reading printed articles can lead to increased cognition and memory [1, 2].
3) If you print your article, take notes in the page margins. While highlighting and underlining can be useful, it is also easy to highlight too much. Rather, write notes in the margins to summarize main points, questions raised for you, or thoughts on how a section or passage applies to your future research. By writing notes, you are actively engaging with the literature and will likely retain more content.
4) Distribute your reading time. We strongly suggest not having "reading days." That is a recipe for procrastination and burnout. Instead, tackle reading in digestible chunks – either by reading two articles and then doing something else or reading for a specific amount of time.
5) Use an annotated bibliography (see the next section) to take notes as you are reading. If you are reading on a computer, have your annotated bibliography in another window. This is a useful method to quickly summarize what you have just read.
6) Devise strategies to avoid procrastination. Disable your phone and email, and (preferably) Internet during your reading times. It is easy to be distracted during your set aside reading times, so simply remove the temptation. Alternatively, print some articles and take them to a coffee shop, where that is the only task you can complete. Find a way to make it happen and make a habit out of it.

4.5 Taking Notes and Starting an Annotated Bibliography (or: Helping Your "Future Self")

For your first literature review, or as you are entering a new research area in which you are just getting familiarized with a body of literature, identify a standardized method for taking notes. While highlighting in a document may be convenient at the time of reading, recalling those ideas across dozens of articles quickly becomes cumbersome. Therefore, we recommend using an annotated bibliography as a useful option for writers. While this is an optional activity, and most people do not keep annotated bibliographies of all the articles they read, they are useful at the beginning of a review. If you are reading this book, you may likely be a novice at writing literature reviews, so we recommend you take this activity seriously. Your *future self* will profusely thank your current self for investing in this additional work.

An annotated bibliography is a repository of the literature that you have read and skimmed so you do not have to remember every piece of literature that you have ever read. It should include the full citation of each piece of literature, and a brief summary of the work and your interpretation of what the value of the piece of literature is to you. Students typically prefer to capture annotated bibliographies in word processing or spreadsheet software programs.

1) **In a word processor annotated bibliography**, type the full citation for each article in your preferred citation style. Underneath each entry, summarize the article, its main findings, and the way that you see the article relating to your research or applying to your literature review. This is also the place to add your commentary on the attributes or limitations of the research, to help you as you begin to synthesize literature or establish the gap.
2) **In a spreadsheet annotated bibliography**, define six columns with the following headers: citation, research questions/topic, methods, results, limitations, and notes. Each piece of literature will then comprise its own row. As you read and skim each article, simultaneously capture standard pieces of information in the spreadsheet. You can also add more columns as you wish (e.g. keywords, stance, and provenance).

Each format has its advantages and disadvantages, so choose whichever is most useful to your cognitive process. Annotated bibliographies compiled in word processors has the added advantage of being useful to share with or print for your research group. Annotated bibliographies compiled with spreadsheet software offers the utility of easily placing literature in different tabs. Use Activity 4.2 to launch your annotated bibliography.

Activity 4.2 Start Compiling an Annotated Bibliography

Anticipated Duration: 1.5–2 hours here (but you will keep working on it as long as you are collecting and reading literature!)

Decide what format (word processor or spreadsheet) that you would like to use for your annotated bibliography. If you are unsure, start with a word processor.

1) Open one of the articles in your "read" folder from the previous activity.
2) Enter the full citation for the article using the appropriate style (e.g. IEEE, APA, ASME). Take the time to format correctly, including the volume, issue, and page number information.
3) Choose one of these options:
   a) Enter all the citations for all the articles in your "read" folder, and then go back and write the summaries of the articles, or
   b) Read one article and complete its summary before starting with the next article.

   Advice: We recommend doing Option A for the number of articles you intend to read in a single work session. If your goal is to read three articles, write the citations for those three and then complete them to signify to yourself that you are accomplishing goals.
4) Summarize of the articles in narrative form. In other words, each summary should look like a paragraph with full, grammatically correct sentences. You will not remember how your bullet-point notes relate to each other several months from now, or what you had intended to do with that article. If you take the time to write thoughts in full, complete sentences, you are solidifying your new knowledge in your memory, explicitly thinking about the meaning of and connections between your thoughts, and most importantly, you will be able to understand your own thought process after any period of time.
5) Continue this process for each article that you read and skim, such that you will compile a long record of all the articles you have read.

Warning: Our students do NOT enjoy working on annotated bibliographies when we introduce them as an assignment, likely because at the time it does not seem like *real* writing. But they thank us later, and you will too.

You will quickly reap the benefits of your work, so really, all the work you invest is only helping your future self. It is much easier to consult your annotated bibliography when you think to yourself, "I know I read that one article that talked

about ...." instead of just opening all the literature in your folders or your reference manager. On a pragmatic level, an annotated bibliography also documents your hours of reading work for your advisor, such that when she or he asks you what you have been working on you can show them rather than just saying, "I've been reading a lot." (Advisors REALLY like this!)

What comes next? Well, now the rubber hits the road, and it is time to build your annotated bibliography and read/skim the articles you have found. Activity 4.3 guides you through reading or skimming the remaining literature that you found.

After you read or skim each document, record your notes in your annotated bibliography. Lest you think that you will be done reading literature after this point, be aware that searching for literature is an iterative process, and you will be constantly collecting and reading more literature throughout the process.

Activity 4.3 Read and Skim to Build a Base for Your Literature Review

Anticipated Duration: 60 minutes per session, continued throughout the writing process

Continue to progress through the literature in your "read" and "skim" folders, taking notes on each in your annotated bibliography. When you are done reading and skimming, sort your literature into subfolders to effectively organize them so you are not confused as to what literature you have already read, summarized, and uploaded into your reference manager.

Alternatively, go back into the literature to find more articles to read and skim. Typically, it is good for students to have approximately 50 closely related articles (i.e. closely related enough that they would be in your "read" folder) to reference when organizing a literature review. Depending on your time frame, you might scope this down to a smaller literature review.

To collect more literature, use the previous strategies for finding relevant literature, but at this point, it is a great idea to mine the references sections of some of the works that are most closely related to your research project. You can then track down the citations you do not have yet by enlisting the help of your institution's libraries resources or online resources.

Take breaks between reading and skimming sessions. Remember to keep saving your annotated bibliography and celebrating your successes as your annotated bibliography grows and you find you are learning more about your field. Activity 4.4 is a guided skimming exercise, if you need extra facilitation for your "skim" articles.

Activity 4.4 (Optional) Facilitated Practice in Skimming Literature

Anticipated Duration: 60 minutes at a time

Select one article in your collected literature.

1) Based on the title and abstract, predict what this article will be the most useful for.
2) Set a timer for 10 minutes.
3) Following an appropriate skimming schema, skim the article for main takeaways.
4) Record your takeaways in your annotated bibliography.
5) Repeat with several more articles, for no longer than an hour (six articles) at a time.

References

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5

Finding Connections Between Literature

At this point, you have read or skimmed many sources and taken notes in your annotated bibliography. Perhaps by this time, you are noting some overarching themes or main topics of interest and can identify some of the main research camps in your area of study. We hope you can start to identify the main players in your research discipline based on the principal investigator (PI), who may or may not be the corresponding author. Remember that the PI is typically not the first author in engineering disciplines and often takes the last-author spot.

Activity 5.1 provides the opportunity to return to your annotated bibliography or literature folder and identify those main players and overarching themes.

Activity 5.1 Identify Main Players and Preeminent Themes in Literature

Anticipated Duration: 10–15 minutes

The *main players* (noteworthy scholars who publish often in this area) include the following research groups at the following institutions:

Researchers (note the PI)_____ Institution or University_____

_____ _____

_____ _____

_____ _____

_____ _____

The overarching themes, topics, or main conversations that people are addressing in the literature seem to be the following:

_____

_____

_____

_____

So, You Have to Write a Literature Review: A Guided Workbook for Engineers, First Edition.
Catherine G.P. Berdanier and Joshua B. Lenart.

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Without realizing it, you probably have started to identify patterns in the literature that will help you outline and write your literature review. Human beings are oriented to identify patterns, so recognizing the patterns in your literature is a natural part of the process. It also represents your socialization process as a member of your academic discipline.

As you read more literature, the conversations within the research become clearer, and you are able to remember who is doing what more easily. It seems difficult to keep everyone straight at first, but you will find over time that as you peruse other papers' literature reviews, you will be able to quickly recognize papers that you have already read. Once you begin attending conferences, you will hear talks by these researchers; you may even meet them or their students to discuss the work. In this way, research and professional development combine, facilitated through writing and literature.

5.1 Identifying Overarching Themes and Topics in Literature

As you continue to find, review, and incorporate sources into your literature review, it is important that your sources interact one with another and do not just comprise a summary that describes one source after another. In our own classrooms, we encourage students to think of research not as one individual's research effort but as part of various research *camps* or, to pull on the metaphor used in Chapter 2, *conversations* at a science party.

For example, consider the field of water resource engineering, a subdiscipline of civil and environmental engineering. At this particular science party, there are several groups talking about different aspects of water resource engineering. One conversation might focus on watershed cleanup efforts, techniques, and technologies – all the people who specialize in this area might all be hanging out with each other. Another conversation might focus on the effects of oil pipelines on a landscape and their potential disturbance to a watershed. Another conversation might focus on chemical processes involving wastewater treatment plants. And finally, another conversation might focus on hydroelectric generation and effects on water systems and resources. All of these people are attending the same party (i.e. are in the same field) but engaged in different conversations. Sometimes it is hard to identify the commonalities between the conversations, but with a closer look – just like at a real party – people mingle and cross talk. Suddenly, these seemingly separate conversations all reveal their commonality. For example, factors, such as water flow rates, temperatures and gradients, nutrient loads, and historical precipitation data in a given region, matter for all of these research areas.

In the majority of literature reviews that frame a journal article, conference publication, or report, readers are only interested in identifying the conversations that are happening in the areas that impact their own research. By identifying areas of overlap, you learn the landscape of the field and work to then establish how your work builds upon what have been done before. If you are compiling a *comprehensive* literature review, which covers an entire topic area/subdiscipline, you might explore multiple conversations. We discuss establishing and justifying the gap in the literature later in this chapter. It is difficult to keep track of which articles cover which topics, though, especially at the beginning. Activities 5.2–5.6 offer a series of strategies to guide you through this process.

Activity 5.2 Map Main Themes Using Sticky Notes

Anticipated Duration: 90-minute sessions, as many as required to work through literature

This activity is designed to help you identify the main topics of interest within articles you have found. Before you start, print 5–10 articles that are *most relevant* to your research project. These might be articles written by your research group and/or those from well-respected journals. Identify articles that are relatively recent (within 5 years) to ensure you are creating a picture of the current state of the field.

To complete this activity, you will need

1) Your articles, making sure you note the first author and year.
2) Lots of sticky notes (if you do not have sticky notes, cut slips or paper or take notes in a word processor).
3) A pen.
4) A workspace (e.g. table, whiteboard) where you can eventually organize your sticky notes into a mind map.

Go through each article and write notes related to the corresponding topics and methods. Likely, these notes will not come from the literature review section (because that is the author synthesizing the body of work to date). Instead, you will make note of methods used, perhaps the novelty in the methods, what they found, and how their results contribute to the wider community. You might keep track of what research questions they answered, and to what extent. Use as many sticky notes as possible. Keep your notes brief and limit each sticky note to one phrase or idea. (Do not forget to note the author and year of article on each sticky note so you can cite the appropriate article later.) Do not overthink this process – if a sticky note is not useful later, just discard it. For now, it is better to have too many than too few. If one of your articles turns out to be a dud, simply select another one.

(Continued)

Activity 5.2 (Continued)

You will have a giant pile of sticky notes when you are finished. Sort these notes into common piles. Perhaps there are several different methods that the scholars in your field use to measure a particular phenomenon; you might assign a different region for each methodology, grouping like things together. Sort or categorize the sticky notes in a way that makes sense to you, creating smaller piles along the way. After you have sorted your notes into major categories, see if there are any larger categories that can be further organized into minor categories. Label each category with an overarching theme or note to yourself so you remember what the theme was.

- Take a picture of your workspace at this point and of the different regions of your mind map. Make sure you can identify easily what was sorted together when you revisit the pictures.
- Save your piles of sticky notes because we will return to them in Chapter 6 (Activity 6.3, specifically). Organize these notes in envelopes, baggies, or paperclip the piles together.

5.2 Identifying "Synthesis" of Literature in Action

As we have discussed, the characteristic that makes a literature review strong is that it synthesizes literature. In other words, it tells a story using literature as evidence to communicate the state of the field, such that a research gap is established. The word *synthesis* is important to help readers interpret the important works and trends in the field by cleverly weaving together language. These connections are often drawn using linking words and phrases in the form of comparisons and contrasts. Table 5.1 shows some of the most common synthesis, or

Table 5.1 Examples of linking words used to compare and contrast.

Linking words and phrases showing comparisons	Linking words and phrases showing contrasts
• Similarly	• Alternatively
• In addition	• However
• Moreover	• Despite
• Furthermore/further	• In spite of ...
• Following this work ...	•
• Therefore	•
•	•
•	•

linking, words and phrases. You can fill in more if you come across others in your review of literature.

So, now you will have a chance to identify synthesis in action using an article from your selection in Activity 5.3. (Sometimes, you will note a complete lack of synthesis – literature is not perfect!)

Activity 5.3 Read Analytically to Identify Synthesis Patterns

Anticipated Duration: 10 minutes

Select your favorite article from the batch of articles you just thematically analyzed. For this activity, you will do a close analytical read of the literature review. Turn to the literature review (or introduction if this article does not have a section labeled, "literature review").

As you read, circle the words or phrases that show connections between pieces of literature. Carefully note the ways in which the author is crafting the argument. If there is a lack of flow, or you feel the authors could have more effectively used linking words, jot a note to yourself. Literature is not perfect, and you may notice literature reviews that are not well written. It is important to be able to critique the literature both in terms of technical ideas as well as writing quality. Reflect on how a poorly written literature review section makes you feel. Are you burned out trying to understand the connections between the articles? Does it annoy you that the authors seemingly did not spend time revising? Do you intrinsically have more faith in an article with a strong literature review?

If you come across additional linking words (comparisons/contrasts) than the ones listed in Table 5.1, add these to your list.

Activity 5.4 presents a way to investigate patterns of argument that are common in engineering literature reviews, using one of the articles that is particularly relevant to your own research.

Activity 5.4 Read Analytically to Deduce Synthesis Patterns: An I-Spy Game

Anticipated Duration: 15–20 minutes

Select your favorite article from the batch of articles you just sorted. For this activity, you are going to conduct a close analytical read of the literature review. Turn to the literature review (or introduction section, depending on heading names). As you read, circle or highlight the following elements:

(Continued)

Activity 5.4 (Continued)

I-Spy …

- … A statement of motivation. (Hint: It answers the question why the readers should care about the topic.)
- … The purpose statement. Sometimes it is explicit (e.g. "The purpose of this paper is to …") and sometimes it is more veiled.
- … The big topics of conversation related to the paper. Identify those big topics in the space below:

- … Promising opportunities or the gap in the literature.
- … The *ways* in which the authors use literature. Are the citations at the end of the sentence, in the middle of the sentence, after author names? Is there meaning associated with the reference placement within a sentence?

The last "I-Spy" of Activity 5.4 should whet your appetite for discussing the rhetorical functions of citations and their placement. We will discuss this more in Chapter 8, but we want you to have a chance to start thinking about it now before discussing a more thorough analysis of the ways in which we use literature later.

5.3 Drawing Connections Between Literature

Armed with your list of linking words and phrases, Activity 5.5 is a short exercise that our students find useful when connecting literature. It is not long, but we challenge you to find connections between literature, to practice deeper synthesis. Who knows, you might find connections that you have not previously identified.

Activity 5.5 More Practice Finding Connections

Anticipated Duration: 5–10 minutes

Open your annotated bibliography document, where you have summarized many articles. At this point, you might have annotated anywhere from 20 to 50 articles. For this activity, arbitrarily select two numbers within the total number of articles you have summarized (you can use a random number generator to make this even more random), and work to find ways to connect the two articles. For example, if our randomly selected numbers are 2 and 25, then we would look for the 2nd article and the 25th article in the annotated

Activity 5.5 (Continued)

bibliography, and work to articulate the connections between those two. Some articles will be easier to connect than others, and we challenge you to go beyond surface-level characterizations here.

Do this at least five times, perhaps with a partner, challenging one another to deepen the level of connection you make. Use linking works to show connections, and note any useful revelations.

5.4 Justifying "Gaps in the Literature"

It is one thing to identify research camps and show their interconnectedness; it is quite another to use that information to make an argument for your particular understanding of an issue or topic. It is important to keep in mind that literature reviews do not just summarize related sources, but instead bring together past work in order to point the way forward to answering your research question. To convince your readers as to the validity of your claims, you must first convince your audience that you are a practitioner of the same field and that you are a credible source within that field; we call this process *justifying the gaps*.

We will work through an example of how an author establishes a research gap by providing you with an excerpt from a literature review, and then noting *where* and *how* the author addresses the gap. This activity builds on Activity 5.4, the "I-Spy" activity where you found the purpose and/or gap statements, but now we critically analyze where in the literature review that conversation occurs and how the author(s) navigate the gap.

Two rookie mistakes are to simply claim that "no one else has ever done this" or point fingers at how no other literature is any good. These rationales are fundamentally untrue – if research is published in high-quality, peer reviewed journals, it likely has some value, and no research is based on completely new ideas that do not pull from any existing work. Therefore, we examine some sophisticated ways to address the limitations of current literature in a way that gives due credit to prior work, but also adds value to the conversation.

Once again, consider the metaphor of the science party conversation – you do not want to barge into a conversation by claiming that no one else has any valid points. It is also important when writing literature reviews to not make sweeping general statements about the quality of others' work. There are delicate ways to address gaps without alienating yourself. These people will be your peers and colleagues one day and could be your reviewers for this work, so it is not a good idea to make anyone mad with an ill-informed critique of their work.

There are a couple of different strategies for identifying the gap, depending on the landscape of your research field. Envision for a moment a mountainous,

rocky terrain – perhaps in Canyonlands National Park in Utah (United States). A photograph of the landscape (Figure 5.1) shows deep trenches and breaks in the land as well as tall peaks and spires. In reality, we know water has carved away the rock formations, but we will use the image differently to illustrate a metaphor for the landscape of knowledge. Think about the trenches and rocky spires representing the specific topics in your field. Perhaps your work is seeking to add value to one of the existing spires – A LOT of work has been done in the area – your job is to understand a specific aspect of it just a little bit better, adding one more stone to the top of many other works on that topic. Your literature review will be highly focused on that particular topic, and also on the most recent work that supports yours. Your gap statement is justified by the advantages that knowing just a little bit more will be impactful to the research community.

Figure 5.1 The spire formation above the hiker is named "Mother and Child," and occurs in the Maze District of Canyonlands National Park, Utah. Source: Joshua Lenart.

Maybe your research project does not add "one more stone to the top of a spire," but, rather, tries to fill in a trench between topic areas. The literature review for this type of landscape likely covers the most important works that have occurred at the boundaries of two neighboring spires but your job is to establish that there is an important gap between two existing conversations.

The best way to understand how to establish a gap is to study how other researchers do it in their articles. For Activity 5.6, select three articles that are similar to the one you have to write, and identify *where* in the text the authors establish the gap (it may be in a few places, especially in a long document such as

Activity 5.6 How Do Others Identify the Research Gap?

Anticipated Duration: 15–20 minutes

Choose three articles from your annotated bibliography. Ideally, these articles will be ones that are highly relevant to your work, and that you deem to have high-quality literature reviews. With each article, find **where** the authors identified the gap in the literature and determine **how** they established the gap.

Article 1 Citation:

Where?

How?

Article 2 Citation:

Where?

How?

Article 3 Citation:

Where?

How?

a dissertation) and *how* they establish the gap. The *how* pertains to the structure, language, or some other way that they discuss the gap.

Now that you can identify and reflect on how other authors establish the gap in their published articles, you should be able to begin to mimic these trends in your own. You may already – as you have been reading the literature – be formulating your own conclusions on how you are adding value to the research community based on prior literature. Chapter 6 will help you organize your literature review, moving closer to formalizing your argument.

6

Organizing Your Literature Review

Pause to consider what you have accomplished so far. You have decided on your time management strategies. We convinced you (hopefully) that the purpose of a literature review is to synthesize literature, creating an argument that leads to your specific research questions rather than simply being a summary of the literature. You have searched the literature online or through your institution's databases. You have established the infrastructure by which to store and remember your literature. You have begun summarizing it into an annotated bibliography.

You have also started to hone your synthesis skills, identifying connections between some of your favorite and most relevant articles in your collection. In reading these both for form and content, you likely have a mental map of what types of strategies that scholars doing similar work as you often use in their literature reviews. You have even written sentences or small paragraphs that connect some of your collected literature.

All of these activities are useful. You should be able to use the sentences and paragraphs you drafted previously again now in your actual literature review. But to this point, we have been preparing you to feel competent in beginning to write the literature review of your dreams. (Disclaimer: No one ever feels ready or competent to write a literature review.)

But now comes the real work: shaping the narrative, or the story, of your literature review. At this point, you get to think critically about how this literature review is working for you. Whether you are writing a literature review for a journal article that addresses specific research questions, or if you are writing a comprehensive literature review to prepare for a dissertation where you are exhaustively exploring the literature, the needs of *your* literature guide the design parameters for *your* literature review.

So, You Have to Write a Literature Review: A Guided Workbook for Engineers, First Edition.
Catherine G.P. Berdanier and Joshua B. Lenart.

Published 2021 by John Wiley & Sons, Inc.

The first step is to establish your target. What is the purpose of your paper? Write this down in Activity 6.1. If you are writing a stand-alone literature review (or a comprehensive literature review), the purpose of the review is typically to identify the current trends in the discipline or identify the most promising avenues for future research in some area. If you are writing a literature review as part of a manuscript or grant proposal, write the purpose of the paper or grant. In its most simple form, you could write it as, "The purpose of this paper is to explore [X] phenomenon" (though you will likely want to be more specific than that).

Activity 6.1 Identifying the Writing Objective

Anticipated Duration: 5–15 minutes

1) **Write the objective of your paper**. The objective of this paper is to

_____
_____
_____
_____
_____

2) **Write your specific research aims or research questions affiliated with your paper or literature review**. Most papers address one to three specific research aims; the more research aims, the more complex a story you will need to design through your literature review, results, and discussion section. The research aims or questions should directly fill the gap that you will establish in your literature review.
The research questions this paper seeks to address are

_____
_____
_____
_____
_____
_____
_____

6.1 Envisioning the Macrostructure of Your Literature Review

We refer to *macrostructure* as the overall organization, argument, or flow of your literature review, whereas the *microstructure* refers to the arrangement of specific sentences or ideas within a particular topic or section in a literature review.

In engineering disciplines, literature reviews are commonly organized either by topic, temporally (i.e. arranged in order of time), or sometimes a combination of the two. Typically, multidisciplinary projects or projects that examine unique topics with a unique or new method benefit from organizing a literature review by topic because there are many different parts of the project that need to be justified to establish the gap in a niche interdisciplinary area. Extending our mountainous terrain metaphor, this structure is useful for research working to fill in some trench or valley in the literature (i.e. a literal gap).

However, if you are exploring a foundational topic or one that has a significant amount of research already done in the area, consider a temporal literature review, beginning with the emergence of the particular topic or area, and then introducing the literature review in order. This format is also good for new, developing areas where scholars are working in conversation with each other, publishing articles in response to (or to beat out) other research groups as innovators. For these topics, time-oriented organization holds well, but requires that writers comprehensively tell a complete story without missing any important publications.

Regardless of the organization of your literature review, remember that your job is to weave the literature in such a way that it always points to the purpose of your paper. The most effective way to do this is to imagine that the argument of your literature review has a shape – an inverted triangle or a funnel, for example. The most general, broadly applicable citations that motivate your work overall will be near the top of the funnel, often using a string of citations to justify the magnitude of the need or call to action. Then, as the literature review flows through the funnel, the topics of interest and specificity of your citations become more focused toward the purpose of your paper, such that at the end of the literature review, the reader is effectively convinced that there is a need to study what you are proposing and that the answers to your research questions will have intellectual merit for the community.

If you choose to arrange your literature review by different topics, which is one of the best strategies for long literature reviews, each topic will follow the funnel shape, perhaps not starting quite as broadly at the beginning, but ultimately will funnel toward the argument you hope to make. Alternatively, if you are choosing to arrange your literature review temporally, it is up to you to effectively synthesize the literature of how your discipline evolved. This involves the added work of understanding which research groups were established first, what universities or research laboratories are most highly regarded for their work, and also having an appreciation for the *family tree* of academic research: many researchers in an area studied with other influential researchers in the same area; therefore, you should be able to trace researchers through their academic lineage.

Is all this starting to feel overwhelming? How are you going to decide which is which and who is who? Before tackling the organization of your literature review

on your own, let us practice by reading a literature review analytically to discern its macrostructure. We will show an example first, for your review. As a note, you can read any literature review for structure, without needing to be a content expert in that particular field. We are interested in reflecting on how this article is put together, *not* reading it to learn information about the topic. The example we present here mimics exactly what we would like you to do in Activity 6.2. The below example was a draft from one of our students' literature reviews that was later submitted to conference. Note that the references cited are hers, and do not correspond with any of the citations for this book.

Swirling flows are commonly used for enhancing flame stability in gas turbine combustors. The property that makes them suited for this application is a phenomenon known as vortex breakdown[1–9], characterized by the formation of a central recirculation zone (also known as the vortex breakdown bubble) that constantly supplies heat and active radicals to the base of the flame, enhancing its static stability. This recirculation zone is created when the degree of swirl exceeds a certain critical number and the pressure gradient along the axis is too large to be balanced by axial flow. In combustors, the occurrence of this breakdown bubble depends largely on the swirl number and the combustor configuration, particularly the dump ratio (ratio of the combustor area to the nozzle area) and the exit boundary condition.

With increasing swirl, there comes a point when this vortex bubble becomes unstable and periodically precesses about the central axis of the flow, forming the precessing vortex core (PVC). PVCs are a self-excited global instability that lead to large-scale helical disturbances in the flow field.[10,11] In combustor systems, the occurrence of a PVC is a function of the swirl number, the flame shape, fuel/air mixing, combustor configuration, and equivalence ratio.[12] Oberleithner et al.[13] showed that the formation of the PVC depends on the density and temperature gradient near the combustor inlet. Freitag et al.[14] showed that the PVCs significantly enhance fuel air mixing. Steinberg et al.[15] showed that in some cases, the PVC can even couple with thermoacoustic fluctuations.

Previous work from our group has shown, through a spectra analysis of the flow, that response of the shear layers to acoustic forcing is suppressed in the presence of a PVC.[16] This result has been explained by means of a linear stability analysis, showing that the formation of the PVC results in increased shear layer thickness. This increased thickness leads to a progressive weakening of the Kelvin Helmholtz mechanism that ultimately causes reduced shear layer receptivity.[17] This result was shown experimentally for a moderate range

of forcing frequencies and amplitudes, but more thoroughly in the linear stability analysis over almost two orders of magnitude in forcing frequency. The implications for this result are important to the prediction of thermoacoustic instability in combustion systems. As velocity coupling, where heat release rate oscillations are driven by velocity oscillations in the flow field, is a major contributor to the thermoacoustic feedback loop, the suppression of coherent vortical velocity fluctuations that modulate the flame at the acoustic frequency can be a direct method of suppressing combustion instability. To achieve this goal, however, accurate prediction of the dynamics of the PVC must be achieved at realistic combustor conditions, which include high turbulence intensities.

Several methods have been used to extract coherent structures like the PVC from a turbulent flow field. Most of these techniques rely on a triple decomposition, proposed by Hussain and Reynolds,[18] a method based on the premise that every fluctuating entity can be decomposed into the mean value, a coherent component, and random oscillations. They originally used phase averaging to extract the coherent structures. This method, however, requires knowledge of the cycle period and neglects any information about cycle to cycle change of the coherent oscillation, or 'phase jitter.' Midgley et al.[19] used conditional averaging of the Reynolds-decomposed velocity field to separate 'true' turbulence and large scale structures. Some approaches have used frequency domain filtering. For instance, Liou and Santavicca[20] used a low pass digital filter and Brereton and Kodal[21] proposed a method to estimate the power spectral densities of the data to yield an optimized frequency domain filter. Proper orthogonal decomposition (POD) and has been used to isolate coherent structures.[22–26] Hydrodynamic stability analyses[22] have also been used to isolate large scale instabilities.

The goal of this study is to characterize the influence of turbulence on PVC dynamics and identify flow regimes where this influence alters the PVC dynamics. We make this characterization by quantifying the phase jitter of the coherent structures that arise from the PVC instability, where phase jitter is the cycle to cycle variation in the behavior of the coherent structures.[27] Our hypothesis is that variation in phase jitter occurs because turbulence is affecting the coherent motion of the PVC. If that is the case, the magnitude of phase jitter could be used to quantify the degree of influence that turbulence has on the PVC.

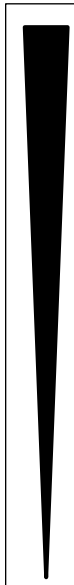
We observe the variation in PVC motion with increasing swirl number and quantify phase jitter in both space and time. We also analyze the behaviour of a non-linear oscillator to help explain the experimental results that we observe. The response of this oscillator provides insight into the dynamics of

a non-linear system that is systematically influenced by both coherent and incoherent oscillations and the regimes where each of these oscillations dominates the system. The analogy between the behavior of this oscillator and the flow field dynamics of our system allow us to interpret our results and reconcile the different sources of phase jitter in the flow field.

The results of this study are pertinent to our previous work in two important ways. First, understanding the role of turbulence in the behavior of coherent oscillations is an important step towards improving theoretical predictions of these instabilities. While turbulence is now regularly accounted for in the development of the base flow through an eddy viscosity model, current predictions do not account for turbulence in any dynamic fashion. This study seeks to understand if this omission is critical or not for understanding the dynamics of the PVC. Second, our previous results showed that the PVC could have a powerful influence on the dynamics of the flow field, suppressing the receptivity of the shear layers to external perturbations. This method was previously proposed as a way of suppressing thermoacoustic oscillations in combustor systems, as the velocity-coupled flame response would be suppressed if there was no shear layer response to acoustic oscillations. Utilizing this method of thermoacoustic suppression, however, requires better knowledge of the PVC dynamics in realistic combustor flows, which typically have very high turbulence intensities. Whether or not the PVC plays a critical dynamical role as turbulence increases is still an open question, and one we begin to answer with the present study.

This literature review has a total of seven paragraphs in which this author presents her research questions and purpose in a distributed way. In Paragraph 3, she notes that this paper would extend her group's research ("Previous work from our group has shown ..."). Then, after discussing her group's work in conjunction with methods proposed by other researchers, the review identifies the research objective in Paragraph 5 ("The goal of this study is to characterize the influence of turbulence on PVC dynamics ...") and positions the specific research question at the end of the literature review after noting why they need to conduct the present study ("Whether or not the PVC plays a critical dynamical role as turbulence increases is still an open question, and one we begin to answer with the present study").

In the venue to which this paper was to be submitted, the introduction and literature review were combined into one section entitled, "Introduction." Next, we will analyze the introduction's *macrostructure* by mapping brief summaries of the paper on an inverted triangle shape. In other words, our job is to summarize each paragraph's function in a short sentence – no need to be overly specific or to even understand all the technical elements.



Paragraph Number And Summary Sentence
Paragraph 1. Swirling flows are important in combustors, particularly the phenomenon of vortex breakdown.
Paragraph 2. At times, swirl can become unstable (causing PVC) which can be affected by a variety of conditions.
Paragraph 3. The group doing the study has significant experience researching PVCs to reduce instability, but an outstanding challenge is to predict PVC dynamics at realistic conditions.
Paragraph 4. There are a variety of methods used to understand flow structures, some of which are limited.
Paragraph 5. The goal of the present research is to characterize influence of turbulence on PVC by using phase jitter methodologies.
Paragraph 6. This research will explore variation in PVC motion with a variety of variables and try to model it using a non-linear oscillator.
Paragraph 7. The results of this study are meaningful for several reasons, and the outstanding research question is whether or not the PVC plays a critical dynamical role as turbulence increases.

If you read these sentences chronologically, they read as a summative narrative of the overall literature review. Strung end to end, this narrative (our interpretation via summary sentences) reads as follows:

> Swirling flows are important in combustors, particularly the phenomenon of vortex breakdown. At times, swirl can become unstable (causing PVC) which can be affected by a variety of conditions. The group doing this study has significant experience researching PVCs to reduce instability, but an outstanding challenge is to predict PVC dynamics at realistic conditions. There are a variety of methods used to understand flow structures, some of which are limited. The goal of the present research is to characterize influence of turbulence on PVC by using phase jitter methodologies. This research will explore variation in PVC motion with a variety of variables and try to model it using a non-linear oscillator. The results of this study are meaningful for several reasons, and the outstanding research question is whether or not the PVC plays a critical dynamical role as turbulence increases.

A-ha! The author has cleverly led us through the relevant conversations related to her work and justified how her work adds value to the ongoing conversations. By the end of the literature review, we not only have an appreciation for what value the results will add, but we are also clear on the question this paper seeks to address.

Activity 6.2 gives you the opportunity to analyze the macrostructure in your collection of literature.

Activity 6.2 Analyze a Literature Review for Macrostructure

Anticipated Duration: 30–45 minutes

1) Select an article that you think has a strong literature review. Identify an article from a tier-1 journal rather than a conference paper.
2) Count the paragraphs. How many paragraphs do the authors use to make their claim and establish the research gaps?
3) Go to the end of the review. How do the authors present their research gap? Do they present specific research questions or explicitly state the objective or purpose of the paper?
4) Is the review combined with the introduction? If not, what differentiated the introduction from the literature review for this article?
5) Using the provided diagram, number the inverted triangle with the number of paragraphs in your review. These numbers will correspond to the number of paragraphs in the literature review you have selected, starting with Paragraph 1 at the top (the broad part) of the triangle and ending with the largest number, corresponding to the number of the final paragraph. Now, go through your literature review, paragraph by paragraph, and summarize the point of each paragraph in a sentence or a descriptive phrase. When you get to the end of your literature review, each number will have a sentence next to it summarizing the purpose of the paragraph. If the authors use headings in their literature review to separate sections of the literature review, write those down in between the appropriate paragraphs.

If you read your sentence in order from top to bottom, do they form a cohesive narrative? They probably are pretty close. In addition, you may notice that the sentences you have written about each paragraph more or less mimic the first sentences of the paragraphs. The inclusion of powerful and meaningful topic sentences is one of the features of strong writing.

6.2 A Discussion on Topic Sentences: The First Sentence of the Paragraph

The first sentence of a paragraph is a statement that sets up the reader to digest the remainder of the paragraph. In writing, this sentence is sometimes called a *topic sentence*, but we prefer the term *umbrella sentence*. Just like an umbrella covers its user (and only the people under it) to keep out the rain, the umbrella sentence covers the topics that are only part of that sentence. To advance the argument, you will need an additional paragraph and an additional umbrella sentence.

In a given paragraph, after the topic sentence/umbrella sentence that comes first, the remainder of the paragraph is dedicated to supporting evidence that proves the point of the umbrella sentence. Pretend it is the evidence in a courtroom that a lawyer would use to justify a statement. Rather than physical evidence, though, we have citations and other colleagues' research to justify our point.

Not all literature reviews are well written, even though they have been peer-reviewed and published. You may find some paragraphs that simply report out on the literature, without synthesizing it well. You may also find paragraphs that do not have effective topic sentences. This is an important fact to remember – that all writing can always be improved. We note these issues and reflect on them – not to justify poor writing – but to note areas where we can learn from what we feel others could have improved upon.

6.3 Creating a Macrostructure for Your Own Literature Review

Now that we have guided you through an analytic reading of another researcher's literature review, and you have done this for an article of your choosing, it is your turn to begin to scope the macrostructure for your own literature review. The easiest way to do this is to begin again with an inverted triangle. At the bottom of the triangle, write the research questions or objective that you articulated earlier in this chapter.

Remember Activity 5.2 with the sticky notes? The themes you identified and organized into the common regions of your mind map are going to be the buckets of information that you will probably need to address in your literature review. You can write some words or phrases representing these topics in the side of the box, and perhaps other topics that you think you might need to talk about as well.

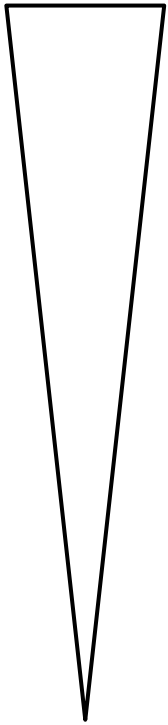
Now, your job is to start putting them in order. (If you want, use sticky notes or slips of paper for this step; they are convenient and easy to rearrange.)

Once you have your topics arranged, work to articulate full sentences that can serve as preliminary topics/umbrella sentences for these paragraphs. Just like when we did this analytically for existing literature reviews, there should be a flow of ideas. One way to think about this activity is like doing a geometric proof, where you start with a given and you must progress logically and linearly to a conclusion. Similarly, the evidence that you present must march systematically in a way that leads your audience to believe your claims, understand where your research is situated with respect to the wider community, understand why your results have impact.

In Activity 6.3, you will cultivate a macrostructure-level outline for your own literature review. Go ahead and write it out in the image below, starting with your motivation at the top and ending with your specific research questions.

Activity 6.3 Craft the Literature Review for Your Literature Review

Anticipated Duration: 15–30 minutes



Therefore, the research questions this paper seeks to address are –

The organization of the macrostructure is not locked in stone, and you will likely iterate on this slightly as your literature review progresses. Once you arrive at a final organization, you should be able to easily place any (relevant) newly found source within the framework you have established.

REMINDER: You should still be spending time collecting, reading, and summarizing new literature that will build out the paragraphs within your macrostructure. Alternate book activities with finding/reading literature to optimize your time. Make sure these new articles are captured in your annotated bibliography.

7

Writing the "Ugly Draft"

This is the most difficult chapter. Saddle up.

The "ugly draft" is the most painstaking part of the writing process, and it does not get celebrated enough as a milestone. By the end of this chapter, you will have constructed an ugly draft of your literature review. The ugly draft is written as an extension of the macrostructure outline that you generated in Chapter 6. However, if you are not an outliner, skip to the end of the chapter where we briefly discuss a more process-oriented approach to writing the ugly draft. However, first-time literature review writers should work through this entire chapter to develop an extended outline to scaffold the writing process.

Each of these steps will take a substantial amount of time, but we provide the steps to give you direction and accountability as you work toward building your draft. Unfortunately, this is not the work we can do for you, but take solace in the fact that your first literature review is the hardest; they get easier the more you write them.

7.1 Twelve Steps to Building Your Literature Review

Think of the following 12 steps as an intentional practice that might feel clumsy, uncertain, and difficult as you begin working through each. But with practice and deliberate attention to consistently working through each step, the process will become more familiar.

1) Collect any bits and pieces of writing that you have and paste them into a digital document. Title your file and save it somewhere logical on your computer. This is also the time that you can translate the topic (umbrella) sentences into your outline, preparing to add content as "evidence" to support those sentences.

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2) Start adding evidence into the outline. You may already have some evidence – you generated some in the form of themes/citations in Chapter 5 on the sticky notes from Activity 5.2. Integrate this work into your outline where you think it fits best. Some of these placements may be awkward or only fit tangentially into the outline – this is okay, we use the word *best* for a reason. Write a sentence about that citation in a way that pertains to the value of that article and put into the macrostructure. Worry about flow and microstructure later.
3) Filter through the compiled literature that is directly related to the project. Ideally, you will have all this literature corralled in your annotated bibliography (Chapter 4). Go through your annotated bibliography, translating main takeaways from your annotated bibliography into the outline for your literature, along with the sources.

   Note: Engineering and science literature reviews DO NOT direct quote from articles in the way that those from the social sciences and the humanities do. Instead, you will paraphrase research results.
4) Likely, even when you get through all the literature you put into your annotated bibliography, you still will not have the depth or breadth of evidence that you need to fill out your literature review. Once your brain is organized in terms of what information you will need, it is time to go back through the literature you have saved in order to fill in the gaps. If you did not do an annotated bibliography in Chapter 4, you will simply go through all the literature that you saved – document by document – articulate the main contributions of the piece, and write one to two sentences about it in the appropriate location in your literature review outline. Again, do not quote directly from the paper, because direct quotations are not common in engineering literature reviews, and it makes the possibility of committing accidental plagiarism more likely.
5) You may feel like you are jumping around from place to place in the outline depending on the order of topics and how you saved them, and the scope of the literature review. If this bothers you, use the titles of the papers to help you distill down the articles that are probably relevant to a particular paragraph or theme that you would like to work on.
6) You will likely have areas of your literature review that have few or no citations yet. **Do not let your lack of citations keep you from making progress**. It is okay to write the sentences that are the logical next steps in the argument, leaving the word "CITE" at appropriate places in the draft. Do not let a lack of literature ruin your flow.

   When you are stuck in making forward progress in terms of generating words, you can dive back into the literature to search for articles in specific areas, convening on more focused search terms.

7) Proceed through this iterative evidence-gathering and organizing process until you have sufficient evidence under each umbrella statement in your outline. *Sufficient* is a relative term, obviously – you can aim for 5–10 articles/pieces of evidence in each. You may also include your critiques of the results/main takeaways too, because your literature review is also a commentary on the gaps in the literature.

   Reminder: You will still be spending time collecting, reading, and summarizing new literature that will build the paragraphs within your macrostructure. At this point, you will likely be iterating between finding literature and reading literature both generally for your literature review, and also to fill specific gaps in your literature review. Make sure you still keep track of these articles in your annotated bibliography.

8) As a last step, go through the extended literature review outline that you created, and work to smooth your sentences. All sentences written should be grammatically correct and have citations indicating where that evidence came from. For some more ideas on filling in paragraphs that do not seem to be substantial enough, skip to Section 7.2 and then come back here.

   Just as in the engineering design process, after initial ideation and prototyping there are significant iterations on design, so too are there in the writing process. You have drafted the macrostructure and have been building out your extended outline as full sentences, adding in references and short summaries where you can. The next goal is to start kneading each paragraph or section to make it start to look and sound like a literature review.

9) Select one of the sections in your literature that you are happy with or proud of (yes, at this point you should have several passages that are relatively polished). Perhaps the section you choose is the one you have read the most about, or perhaps it is the section with the technical content you like or understand the most accurately. Great. Just work with that section. If you need to add space in your document around that section to separate it from neighboring sections a little bit, go ahead and do that now.

10) Remember the connecting words that we identified in Chapter 5? Now is the time to bring them into play. How are the references discussing similar topics relating to each other? How do the findings or methods compare to each other, as they pertain to your overall goals for the paragraph as outlined in the topic (umbrella sentence) for the paragraph?

    Work with one paragraph at a time. Place the sentences next to each other and determine what linking words or phrases you need to add to connect each to the other and sound like a literature review. Add these as you need to: use connecting words to communicate your interpretation on how these pieces of literature work together (remember, your job is to *synthesize and interpret*, not simply report).

Feel free to edit or revise the topic or umbrella sentence at the beginning of each paragraph to best describe the paragraph. After presenting the evidence that specifically supports that umbrella sentence, you can consider adding a sentence of interpretation at the end of each small paragraph, giving your interpretation of the meaning of the synthesis, remembering that the literature review is *your* view of the story, pointing toward *your* research questions. Remember to self-edit – you could draw all kinds of contrasts that are not at all relevant to your goals for the paper: just because you can write it, does not mean you should.

If you feel like you are struggling with immediately justifying whether the sentence you are writing belongs in a given paragraph, make a comment in your document, and write "The purpose of this paragraph is to ..." (filling in what, in your words, the role of that paragraph is). For example, it could read something like, "The purpose of this paragraph is to justify the importance of conducting experimental research to confirm computational results." In the case of this example, getting "into the weeds" discussing the context of one study's methods might deter from the overall purpose of the paragraph. For additional help articulating sentence or paragraph roles, see Section 7.2.

11) A paragraph is typically five to seven sentences long, depending on the venue and formatting, with occasional opportunities for using longer or shorter paragraphs to add emphasis. If your paragraph extends past seven sentences, it is likely "drifting" in focus or there is something you are discussing that might warrant its own paragraph with its own umbrella sentence.
12) Proceed through your literature review paragraph by paragraph, topic by topic. You do not have to go in order. Feel free skip around to build your confidence in the process, but make sure to challenge yourself not to procrastinate on the sections that you really do not want to do. To conquer the challenging sections, keep breaking your task into smaller "bites" that are easily accomplishable and not so scary. For example, challenge yourself to find and read one new paper on the "scary" topic. Find small, achievable ways to chip away at the sections you are most insecure in writing.

Is Negative Self-Talk Getting You Down?

We are going to deviate slightly from talking about the "how to" of the literature review and engage in a "how to manage self-talk" exercise to reframe and harness your negative emotions into positive ones. This is a touchy-feely subject for engineers, we get it. You do not have to do this if you do not want to, but literature shows it is healthy to engage periodically in reflective practice and STEM students are often not exposed to strategies to cope with the pressure of research career trajectories.

(*Continued*)

Is Negative Self-Talk Getting You Down? (Continued)

Take a moment here to reflect on your writing strategy, process, and the way you feel now that you have reached an intermediate point in your "ugly draft" process. Are you discouraged because it is still ugly? Are you frustrated that it takes you time to dig into each paper to remember what it was about? Are you feeling defeated because with each paper you read, you feel less confident in your ability to research?

These are unpleasant things to think about, but the literature review is a monster that feeds on negative emotions and further compounds the already difficult writing process. Graduate students in particular *will* struggle with negative emotions about writing the literature review, because they can seem to confirm your worst fears about your identity as you develop as a researcher, feeding and breeding insecurity.

Bring these thoughts into the light. Name your emotions, and do not let them get you down. Revisit the ways you frame your milestones periodically when you are feeling frustrated with writing. What are your small successes? What milestones are you proud of? How have you improved since the beginning of your writing journey?

As you work through these steps, continue to celebrate each milestone. When you reach the end of the ugly draft stage, you will be able to find ways to continue to build sections in important ways, and similarly, ways to hone your literature review. This is what we sometimes refer to as the accordion phase of writing: where you find yourself adding a whole bunch of detail or new references into a paragraph, and then whittling out and massaging content until it condenses into a more robust, dense, elegant, and focused synthesis of the literature.

Congratulations on your ugly draft! Go do something nice for yourself. Share your success with a friend or colleague – out loud. The work is by no means done, but you have made substantial and noteworthy progress!

7.2 Strategies to Help You Build and Sculpt Paragraphs: Introducing Rhetorical Moves and Steps in Genre Maps

Perhaps at this point, you are happy that you have words on the page, but you are not really happy with them or you still feel like the literature review is missing pieces to sound like a real literature review. This section will help you envision how your sentences are working together in your argument.

The technique we will show is called a *Move–Step analysis*, used by composition and writing studies researchers. We know that the finer points of these studies are likely not interesting to you (if they are, see Chapter 12 for some resources). However, the results are practically useful for students as they learn to craft literature reviews.

Each sentence plays a role (or more than one) in the argument created by the writer. You can name the roles that sentences play, and collectively, the roles form a "toolbox" that students can use to build an argument and envision how their sentences interact with each other. Our past research [1, 2], based on several genre scholars before us (again, see Chapter 12), has defined such a toolbox of rhetorical strategies specific to academic engineering writing. We present the moves and steps in Table 7.1 as a way for students to consider how the purposes of their sentences work together. A Move is an overarching purpose or category, and the sub-categorical Steps serve to articulate the different functions that might fall into a Move.

Table 7.1 Rhetorical moves and steps that serve as building blocks for engineering literature reviews [1, 2].

Move 1: Announcing the importance of the study	
1.1	Claiming importance of the topic
1.2	Establishing the context
1.3	Stating how context or problem affects humans
1.4	Identifying a technical problem
Move 2: Preparing for the study	
2.1	Establishing the state of the field/current findings (usually citing literature or describing literature cited in a prior sentence)
2.2	Establishing a gap or challenges in literature
2.3	Identifying proposed solutions to the problem
2.4	Acknowledging previously proposed solutions and/or failures of proposed solutions
2.5	Familiarizing readers with scientific background (not establishing context)
Move 3: Introducing the study	
3.1	Stating the global objective/hypothesis/need
3.2	Stating the intended outcomes
3.3	Stating the impact of the study
3.4	Addressing benefits, capabilities, or attributes of the study
3.5	Stating the novelty of the study

There is no *right* answer or arrangement, and the numbering is not indicative of hierarchical order or priority (we use it to visualize argument structure in Activity 7.1). Similarly, it is not necessary or ideal to march in a rigid linear fashion from Move 1.1 to Move 3.5; however, most literature reviews loosely proceed from Move 1 to Move 3 by the end of the literature review, while within each paragraph, sentences may fulfill multiple steps, multiple moves, or may combine in different ways. The writer designs an optimum argument (there is no one right way). By defining the purposes of each sentence and identifying how they relate to one another, writers can more effectively design their paragraphs or perhaps see what they are missing.

We present Activity 7.1 for you to identify the purposes of each of your sentences. Engineers are typically good at visual representation, so this technique may be able to help you identify why certain paragraphs do not seem to flow or why the organization of your literature review seems choppy.

Activity 7.1 Analyze the Rhetorical Moves and Steps in Your Literature Review

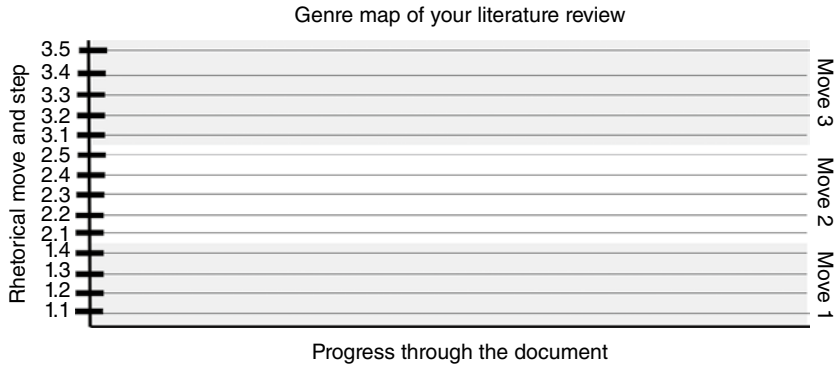
Anticipated Duration: 15–30 minutes

1) Print off a copy of your literature review or place it into a new document where you can reformat without impacting the original document (*For those working on a computer, not on a hard copy*): separate each sentence onto a new line on the document and leave a double space where there is a paragraph break. (*For those working with a hard copy*): keep track of each sentence – sometimes we mark ours up to ensure a sentence did not get forgotten.
2) Assign a Move and Step to each sentence. Some sentences may fulfill more than one Step (or even Move) at a time, so pick the one that you think is most representative. On the graph below, plot each sentence across the x-axis, indicating the position through the document. For example, sentence 1, the first sentence in the first paragraph, would be on the left-most side of the graph. The *y*-axis represents the Move and Step. For example, if you assign the first sentence of the first paragraph a Move 1.2 (Establishing the context), you would place the left-most dot on the 1.2 line. Proceed through each sentence in your document, mapping the Move–Step position based on how many sentences you have.

(*Continued*)

Activity 7.1 (Continued)

3) Now, connect your dots. This plot visually represents the argument structure in your literature review. (You can also do this activity with a published literature review to visualize the argument shape.)



What does your map look like? What trends do you see? Does it generally progress from Move 1 to Move 3? Does it jump around between the Moves and Steps? (It is okay if it does, if the reasons for those jumps make sense and the words of the sentences are crafted to convey meaning.) The Moves are shaded differently, such that you can see patterns: Are you hanging out in Move 1 before progressing to Move 2, and then to Move 3?

If, within a paragraph or over the course of the whole literature review, your genre map is constantly jumping between Move 1 and Move 3 (for example), you may want to revisit if this pattern manifests in disorganization or choppiness in the flow of your literature review. In other words, if the graph is choppy, is the flow of your literature review also choppy? If so, you may want to rearrange some of your paragraphs or sentences within paragraphs. Alternatively, you can hone your language to convey the connections between the sentences to show why they go together in that order.

The other way you might use your genre map is to envision what building blocks you might be lacking. While the Move–Step framework in Table 7.1 is not intended to be a checklist, these moves and the corresponding steps are indicative of common building blocks in engineering literature reviews. If you are feeling stuck with writing, you might ask yourself if you have sentences that fulfill these purposes, and use the framework to get yourself unstuck.

7.3 If You Are Not into Outlines … Leverage Who You Are as a Writer to Get that Ugly Draft on Paper!

While most novice writers will find the previous stepwise progression the most helpful for building out a literature review, more advanced writers and those who are more fluent in the disciplinary literature may be able to use other strategies to craft a literature review. When you know your disciplinary community well, you might be able to simply write your argument out, and then go back and fill in or find citations for the necessarily places later, rearranging your ideas to construct an argument. As you become more familiar with your field, these process-oriented approaches may come more easily. There are no judgments though – many well-accomplished researchers still deliberately work through the outline stages of the writing process.

The thing to remember is that no one sees your process, outlines, or ugly drafts unless you share them. The best manuscript is a completed manuscript – just like thermodynamic properties, a successful literature review is path-independent! It does not matter how you get to the end – an effective argument is all that matters.

References

1 Berdanier, C.G.P. (2019). Genre maps as a method to visualize engineering writing and argumentation patterns. *Journal of Engineering Education* 108 (3): 377–393. https://10.1002/jee.20281.

2 Lenart, J. and Berdanier, C.G.P. (2017). A genre analysis of graduate student literature reviews in engineering: toward understanding patterns of disciplinary argumentation (Brief Paper). *IEEE Professional Communication Conference (Procomm)*, Madison, WI (23–25 July 2017). IEEE.

8

Using Citations to Connect Ideas

In addition to building relationships between your citations using your word choice, the way that you reference citations in text carry meaning for your reader as well, further honing those connections. This chapter presents several ways to hone connections between ideas through the use of references.

8.1 The Proximity of the Citation to the Reference Carries Meaning

The proximity of the in-text citation to a given phrase within a sentence indicates the closeness of the relationship between the citation and the topic. These citations formats generally mimic the inverted triangle organization for literature reviews, with the more general forms of citations like string citations occurring near the beginning of the literature review, where you are covering a great deal of literature in a broad brush stroke to set the stage for more specific research. You will see these trends even within paragraphs as well, with more general forms of citations occurring before more specific callouts.

Examples:

Many scholars have found that … . [1-10]
While most scholars use XYZ techniques [4-8], a growing body of literature suggests the emergence of ABC approach [9-10].
For example, Berdanier [11] found that … .

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In revising the literature review and honing connections between pieces of literature, we want to urge you to develop a diverse set of ways to synthesize literature, including the following:

1) String citations.
2) Topic citations within a series of topics (in the middle of sentences).
3) Citations at ends of sentences without being attached to specific names/articles.
4) Specific article/name callouts.

We will discuss each of these in detail because they are all useful heuristics for how to cite literature. In the examples below, note the references in these excerpts are in superscript format, so they cannot be confused with the references we employ in this workbook.

8.1.1 String Citations

String citations are groups of citations that demonstrate how widespread a field, application, method, or other topic is. These citations occur most commonly at the beginning of a literature review and are often used to justify or motivate a research topic or establish its permanence. In string-citing several documents, the author is essentially saying "Hey, all of this is established; we're not going to reinvent the wheel. Rather, let us focus on what really matters." When string citing, cite more than one reference that is related to the broad overarching topic. These should be seminal works and should be by well-known scholars or national reports. There is such a thing as too many references in a string citation – you will rarely see more than five citations in a string citation. The corollary to this statement is that to establish permanence, you will need to cite more than one research group studying that particular topic, especially if your sentence starts with something to the effect of "Many scholars investigate ..." (in which case, you need to cite *many* scholars and not just one). Some examples of string citations are given below.

String Citation Example 1
Some methods, such as SCAMPER and analogical reasoning, encourage solution exploration through assistance in idea generation.[1-4] Though often qualitative rather than quantitative, they guide designers away from mental fixations and towards novel solutions. The nature of these methods makes them difficult to perform digitally. Other strategies, like genetic algorithms and Markov chains, apply intricate formulas to generate satisfactory problem solutions.[5-9]

String Citation Example 2

Physiological studies of the basal ganglia in PD showed its connection with subthalamic nucleus (STN), SN, and the external globes pallidus (GPe).[25-30] The basal ganglia in PD and preclinical PD models have several differences from the normal function. These functional variations include altered firing rates[3,31-32] and increased burstiness and neuronal oscillations.[33-34] Electrophysiological changes in basal ganglia neurons are hypothesized to underlie changes in electric signals of the STN and SN neurons[35-39] by changing the pattern of synchronization of discharges between neurons.[40]

String Citation Example 3

Additive manufacturing (AM) processes have revolutionized several industries, such as engineering, sciences, and arts.[1] As research is constantly improving the effectiveness of AM processes, there is simultaneous need for integrating AM into the engineering design process.[2-4] This growing need to integrate AM into engineering design has resulted in the emergence of design principles specifically aimed at Designing for AM (DfAM).[5-6]

8.1.2 Topic Citations

Topic citations sometimes operate as string citations to also show the breadth of the research. These types of citations are often employed to justify mid-level landscapes or breadths of research fields. The examples below show several ways of using citations in this way. These citations come immediately after the specific topic, rather than at the end of the sentence. The proximity of the citation to the word/author carries meaning (as we will discuss in the following section). Therefore, the citations for each topic in a series need to come immediately after each topic in a list. If all the in-text citations were to come at the end, the readers would have no idea which reference went with which particular topic area.

Topic Citation Example 1

In order to find the best ratio of particles to gas for the heat exchanger, the heat transfer properties of particle-laden flow need to be better understood. Previous research has investigated many different aspects of particle-laden flow such as flow type,[14-21] particle size and material,[15,17] pipe size,[20] and fluid type.[22-23]

Topic Citation Example 2

Origami-inspired folding has been drawing intense interest in research[1-3] and giving rise to novel applications in many different fields such as solar arrays,[4] paper batteries,[5] robotics,[6-7] inkjet printing[8] and biomedical devices.[9] Multiple mechanisms are used to realize origami actuation, among which are light absorption,[10-11] electroactive[12-13] and magnetoactive.[14-15]

Topic Citation Example 3

Thin film alumina (Al_2O_3) is an appealing material for many electrical and mechanical applications.[1-2] Among these include surface modifications,[3] encapsulation barriers,[4-12] coatings,[13-16] dielectric films,[1,17] and thin film transistors.[18-24]

In these examples, you can see that by integrating the citations into the text immediately after calling out a particular topic area, the reader is pointed to the appropriate works that discuss particular topics or contexts and is psychologically set up to better interpret discussions on more specific literature.

8.1.3 End-of-Sentence Citations

In general, citations at the end of the sentence tell the reader that the reference is simply evidence of the content of the prior sentence. Some examples are shown below. In these examples, because the in-text citation is at the end of the sentence, the readers get the sense that the particular reference generally addresses that particular point, but we are also aware of the idea that the reference has its own context, motivation, and findings associated with it.

End-of-Sentence Citation Example 1

Automotive design must accommodate a targeted group of potential drivers. A design that properly accommodates its intended users will yield a product that permits drivers of various sizes and shapes to posture themselves for the safe and comfortable operation of the vehicle.[1] One of the biggest challenges that occurs in packaging design stems from the variability between humans.[2-4]

End-of-Sentence Citation Example 2

In contrast, ML algorithms may be able to both provide fast design feedback in the moment of use while simultaneously benefiting from the vast amount of repository data available today. ML applications use large amounts of data and performance labels up-front to train an artificial neural network (ANN) to make increasingly accurate decisions, predictions, or generated content.[24] Additionally, ANN techniques that manipulate two-dimensional, discretized pixel spaces are well-developed and repeatedly demonstrate success in a variety of recognition and regression applications.[25] Researchers have shown that CAD design files may be discretized into three-dimensional voxel spaces and processed in similar ANNs, ensuring quick and reliable implementation.[26-28]

While it is not incorrect to also use this form of citations to call out a particular author or study, because the citation is not close to the author's name, it does not make as much an impact in the reader's mind as a direct citation (where the citation or year comes immediately after the author's name) does.

8.1.4 Direct Citation

This is the most direct form of citation, where the numerical citation or the year of the publication comes immediately after calling out a particular author in the text. These direct citations will only occur after specifically referring to a particular author, as shown in the examples below.

Direct Citation Example 1

Initial studies done by Cao et al.[37] used computational fluid dynamics (CFD) models to identify the pressure fields of a simple overlap rim seal. In their study, the authors found that a reduction of the rim seal clearance as well as an increase of purge flow suppresses the unsteady pressure fields in the engine's wheelspace. They also used fast response pressure transducers to validate measurements from the CFD model. This study is regarded as a first study that identifies unsteady pressures in the rim seal and sets the initial baseline for continuous development.

Direct Citation Example 2

The topic of complexity reduction has long been studied for nuclear power plants at the system level, sub-system level, and component level. At the system level, Rashdan[1] showed the deterministic optimization which can cover major parameters are not possible. In this study, the optimization of 19 performance characteristics resulted in 524 288 combinations, overload in the optimization process. At the sub-system level, for example, in the secondary system design, Kambiz[2] sought to find the optimum nuclear desalination. In total 16 decision variables with objective functions were used in his work, and the deterministic method for optimization could not be used. Even at component level, because of large combinatorial optimization problems with nonlinear objective functions, Mahlers[3] suggests that the loading pattern problem can not be solved in the successive integer linear programming. These examples show that the global optimization of the nuclear system is prohibited due to interconnected parameters and insufficient computational resources.

In these examples, you will note that the authors do not just call out a study without discussion. They explicitly note what about that study is of interest and what findings were important (of note, those that pertain to the author's goals in their own studies). In the first excerpt in the previous example, the author explains why that study is important ("This study is regarded as a first study that identifies ..."); therefore, interpreting for the reader why that study was included in the literature review.

When synthesizing multiple articles, a good literature review summarizes the purpose of the references. For example, the final sentence in the second example ("These examples show that ...") help the reader understand why those three references were discussed. Without this kind of a sentence at the end of the paragraph, the reader is forced to read the writer's mind and may not have come to that conclusion. Do not make the reader read your mind!

As a note, be aware that in some journals, it is not typical to call out particular authors or articles. In this case, these direct citation styles do not occur at all, and the citations are either in the form of string or topic citations, or are citations at the end of the sentence. Correspondingly, there are also no names or "et al." phrases found in those literature reviews. To decide what is acceptable, plan to seek out examples of the particular venue in which you intend to publish. Work to mimic the patterns of how other authors synthesize literature while acknowledging that sometimes weak literature reviews get through peer review – so what is published is not guaranteed to be perfect.

8.2 Literature Occurs in the Past, but a Literature Synthesis Points to YOUR Future

For the most part, literature reviews in engineering and scientific disciplines are written in the past tense, unless the author is suggesting or noting a trend that occurs over time. While you can and should use variety in the verbs you use to describe the contribution, being too creative can make the work feel read as fiction writing rather than academic engineering writing. As you are writing, it is okay to rely on the same types of verbs (e.g. *investigated*, *found*, and *studied*) and revisit them in the revision stages of writing to avoid repetition if necessary.

As you discuss each article, remember *why* you are citing that article at that place in the document, such that your discussion of that particular article does not overstep the boundaries for what you need that article for. As an example, if you are using an article to identify the prevalence of using a certain method, the method should be the focus, but the particular experimental setup may not be required for the appreciation of that article for your particular purpose. Providing too many details will drag the reader into a spiral of extraneous details.

In the same vein, recall that your readers are an expert audience. Notes on the mechanics behind a particular phenomenon should be comprehensive enough that a novice or student in the discipline will have enough contextual detail to be able to follow the text or seek more information elsewhere but is concise enough that an expert in the topic will not be bored. Here, writers of literature reviews are presented with a bit of a rhetorical conundrum. Clever word choice is the answer to this issue: We can think of them as *sneaky definitions*. Here are a few of our favorite examples.

"Sneaky Definition" Example 1

Treatments plans for most patients are based on a principle of combining multiple modes of treatment. For example, within chemotherapy, multiple agents are combined into a single cocktail to treat cancer. Combining multiple agents increases efficiency because different agents target different phases of the cell cycle.[4] Similarly, Mukai et al.[5] showed that the combination of radiofrequency ablation (RFA) and radiation therapy shows promise for large lung cancers, describing a synergy in which one procedure compliments the second by improving efficiency. Radiation therapy is relatively ineffective during certain phases of the cell cycle. The synergy of RFA and radiation therapy is likely due to cells which are radiosensitized by thermal therapy. Cells remain radiosensitized for up to 24 hours, therefore the efficiency of radiation therapy is increased during that window. This effect is summarized by Dewhirst et al.[6] in his review of the effects of thermal therapy.

In this example, the writer does not assume that the reader knows all the intricacies of chemotherapy, but similarly does not write in a way that insults the intelligence of a reader who is indeed an expert in the field. The star sneaky definition is in sentence 3, starting with "Combining multiple agents increases efficiency ..." which lays out some background without insulting the reader's intelligence. The writer continues to support these statements with literature and specific examples that are relevant to the research being conducted.

"Sneaky Definition" Example 2

There are three widely used methods to model bending or folding behavior: analytical solutions, dynamic methods, and finite element analysis. Analytical solutions focus on fundamental equations of elastic mechanics based on bending theory. Studies conducted by Balakrisnan et al.[18] and Tajeddini et al.[19] used analytical methods to model beams composed of piezoelectric material as actuating material and a passive layer, solving the bending curvature under a given electric field. However, the major limitation of this method is that the theory assumes that bending happens in one single plane, but negligible curvature in the orthogonal plane.

In this example, the sneaky definition is found in the second sentence, "Analytical solutions focus on fundamental equations of elastic mechanics based on bending theory." This is not a reductionist definition of analytical solutions, and seamlessly blends in the overarching topic sentence (which guides readers into the three methods that will be discussed in the literature review) with the specific references, and guiding readers gently into understanding the affordances and limitations of the analytical technique.

"Sneaky Definition" Example 3

AM enabled CPP systems are highly flexible, able to be changed and scaled easily to accommodate an array of manufacturing needs, and are able to produce a wide range of geometries,[23] which can include complex or internal features that would be difficult or costly to fabricate with traditional methods like cutting, milling or casting.[24] Designers use these complex internal structures to fabricate lattice structures for lightweight components with good mechanical properties,[25] as well as to consolidate intricate assemblies of 20 or more pieces into a single solid piece[26] through a process known as Part Count Reduction or Part Consolidation. Part Consolidation not only simplifies the assembly process, but it can improve performance, decrease weight, or reduce risk of failure of designs.[27]

In this example, the author has chosen an integrated way to describe the advantages of additive manufacturing without seeming like a textbook. For example, the definition of part count reduction and part consolidation is sneakily embedded into the paragraph in a way that guides a novice reader to the definition, but does not dwell on it, remembering that the audience for the particular journal likely knows what these terms mean.

One thing that novice writers of literature reviews sometimes struggle with is discerning what details are relevant because, having just read the article, everything seems new and relevant. The difference here is learning to distinguish what is *new* and what is *new to you*. The novelty within the articles have to do with what advances or contributions the article is making to the field; information that is new to you might end up sounding like a textbook because you might inadvertently spend an extraneous amount of space describing details that are well known to the community, or irrelevant to the reason you are including the article in your literature review.

An aside here: If you know that you struggle with procrastination or perfectionism, do not let these comments stop you from writing your ugly draft. Just be aware of them as you enter into the stages of composition that also interface with the iterative revision stages.

Ultimately, recall that your job is to construct the argument that is most useful to set up your research gaps, such that you and your study are the perfect answer to the gap that you have established. Any extraneous details about past studies that do not help build up your argument in the minds of your reader will need to be culled or revised in the editing process.

8.3 The "Accordion Stage" of Writing a Literature Review Will Hone the Density of Citations and Conciseness

One of the most common questions students ask when we introduce the literature review is a version of: "How many sources do we have to have?" This question is problematic on several levels and deters from the approach we are advocating for in this workbook. In the truest sense, literature reviews provide a space in a research project for the researcher to immerse themselves in *all* current and former work in a given area of expertise. To help you answer your own question, revisit the activity in Chapter 3 where we asked you to perform a quick analysis of literature to determine what an appropriate number of citations in an article in your field is. Depending on the venue to which you wish to submit, the approximate magnitude of citations might change (e.g. for a conference paper there may be fewer references than for a journal article). Different journals may also hold different expectations, but, ultimately, the literature review is done when it is done.

In the accordion stage of revision, each sentence will be revised for clarity and conciseness, with the goal of condensing fluffy sentences with neighboring sentences. As such, some direct citations will instead become part of string citations, topic citations, or end-of-sentence citations, and lengthy discussions on one particular article will likely become consolidated to elicit only the most compelling and important points. During this stage, some of your paragraphs will shrink dramatically. When this happens, you have two choices. The first solution is to go back into the literature and collect more references that pertain appropriately to your particular argument in that section, building out the paragraph to the appropriate length and density of citations again. The second option is to merge the paragraph with a neighboring paragraph, if a neighboring paragraph is also short or if it can be easily included. If you choose to merge paragraphs, you will likely need to revise the connection between the paragraphs and the umbrella sentence at the beginning of the newly merged paragraph such that it effectively describes what will be discussed in the new paragraph. This revision is usually not difficult but is required to aid the reader to best digest the upcoming material.

8.4 The Literature Review Is a Political Document

Because one of the roles of the literature review is to establish your credibility as a researcher in the field, in every reference you cite and every source you connect or contrast, there lies an embedded element of judgment. These connections need to be accurate, and the only way to ensure that they are accurate is to continue to read as much as possible in your particular discipline. Some groups approach the same problems through different methods; some use similar methods to approach different problems. Still other groups have competitive relationships. Therefore, to cite one group is to make an alliance with that group and will potentially alienate another group(s).

But most literature reviews cannot possibly be comprehensive; there are too many sources to integrate. So, what is a writer to do? First, through your deep involvement in the literature, you will be aware of who has been a main player in the field, who are more recently emerging, and what groups are active most recently. While you may base most of your research off a certain group of researchers, you can rhetorically "nod" to the other players in a community through string citations or by giving them a callout in the text using direct citations. Since reviewers can be fickle, and because you can guarantee that your reviewers will be highly qualified to review an article about your topic, you should prepare for someone to become upset that you did not cite them.

One option is to do your best in the manuscript stages, asking your advisor, postdocs, and senior graduate students in your laboratory their opinion if you

have missed any key players. Then, you can let the reviewers tell you who you have missed. If you tailor a strong argument and literature review, and then justify your manuscript with rigorous and compelling research, this should not be an insurmountable obstacle. However, it is worth discussing at the beginning of the writing process, because doing your homework at the front end can help you learn more about your field.

9

Revising the "BIG Four" Literature Review Faux Pas

Revision is an iterative process; it is not something that only happens at the end. As you draft, you will integrate revision into your composition and literature searching processes. Because the deep revision and editing comes toward the end, we have not mentioned this issue until now. There are a multitude of texts and references that can cover issues related to English grammar and spelling, the use of voice, and citation style guides, so we will leave these topics to those existing works. If you are interested in learning more about these topics, we have included a list of our favorite texts that address them in Chapter 12. However, in this section, we call attention to four major issues that we commonly observe in engineering student writing, along with examples, rationales for why they are problematic, and potential revisions.

9.1 Ineffective or Missing Topic Sentences

All paragraphs need to have a topic/umbrella sentence that encompasses the scope of the paragraph that follows it. It is not enough of a link that they pertain to the same topic; rather, you should consider all the other sentences in a paragraph and the evidence that proves the assertion in your first sentence. Students typically struggle with topic sentences in one or both of the following two ways: (i) the topic sentence they start with is not supported with the evidence they provide or the paragraph drifts to other topics, or (ii) students tend to start paragraphs with a direct citation that is not a statement sentence about the paragraph to come. We describe these below, and give some examples that lack topic sentences and offer revisions so you can clearly see how much more effective writing can be with the guidance that comes from a topic sentence.

So, You Have to Write a Literature Review: A Guided Workbook for Engineers, First Edition.
Catherine G.P. Berdanier and Joshua B. Lenart.

Published 2021 by John Wiley & Sons, Inc.

9.1.1 All Sentences That Follow the Topic or Umbrella Sentence Should Directly Support That First Sentence

The following example describes a literature review on aggregate particles in turbulent flow, with applications to marine snow. This paragraph has an overarching sentence at the beginning, but it is not effective because the rest of the paragraph does not align with it. In other words, it does not effectively show the scope of the paragraph to come and the subsequent sentences are only vaguely related to challenges with the classification of aggregate particles. It is choppy, with unclear links between the sentences, and the last sentence seems to be at a different level of specificity than the others, especially considering this was one of the first paragraphs in the document, in which the reader would expect more general information.

Ineffective Topic Sentence Example 1
When ignoring human influence on the particles, classification issues have their own challenges with widely varied shapes and non-uniform density distributions within aggregates. Researchers focusing on particle settling are typically interested in drag force and terminal velocities. Early studies developed equations to accurately predict the drag force and terminal velocities for spheres of all sizes. Aggregating particles in nature rarely resemble spherical shapes, therefore Clift et al.[8] expanded on spherical models introducing shape factors to account for volume, surface area, projected area, and projected perimeter. Each new parameter was an attempt to more accurately represent the drag correction factor. Difficulties in measuring volume, surface area, projected area, and projected perimeter were improved using image processing techniques.

In contrast, the revised version more clearly leads the reader through the author's thought process. In order to provide the readers a more general overview, the writer glosses through the early studies and call out the difficulties in working with nonspherical particles before moving to a deep discussion on a particular researcher's work.

Ineffective Topic Sentence Example 1: Revision
For simplicity, early studies focused on research to characterize behaviors for spherical particles.[28-31] However, aggregated particles in nature rarely resemble spherical shapes, therefore Clift et al.[21] expanded on spherical models

(*Continued*)

Ineffective Topic Sentence Example 1: Revision (Continued)

introducing shape factors to account for volume, surface area, projected area, and projected perimeter. Each new parameter was an attempt to more accurately represent the drag correction factor.

Loth[33] presented a model to represent nonspherical particle shapes as ellipses to calculate a more accurate drag coefficient for nonspherical particles at intermediate Reynolds numbers. First, the aspect ratio, using the ratio of a perpendicular major and minor particle axis, can be used to classify regular nonspherical particle shapes (shapes with symmetry such as ellipsoids, disks, cones). Using the major and minor axis length of each regular shape, an overall "ellipsoidal" shape volume was calculated. Next, Loth related the Stokes drag force for this ellipsoidal particle to the Stokes drag force for a sphere of equivalent volume in Stokes regime through correction factors from a previous study.[34]

9.1.2 There Is Rarely a Need To Directly Cite One Article or Author in the Topic Sentence

If there is a direct citation in the topic sentence, the expectation from the reader will be that the paragraph is solely about that reference and should not include information about any other studies. There are times when this is appropriate, particularly if it is the article that is most closely affiliated with your work, and/or if you are building off the specifics of that article in your work. However, if a paragraph directly cites more than one article, it will typically need a topic sentence to help the reader make sense of what is to come in the paragraph, before starting to directly cite and synthesize the specific articles.

The second paragraph in the revised example 1 does directly cite one author in the topic sentence for that paragraph. In this case, it works, because that new paragraph expressly discusses the work of one foundational researcher and is a direct link with the prior paragraph. Most times, though, it is not a good idea to directly cite an article in the topic sentence, as you will see in the example below.

This example paragraph, from a literature review about nuclear storage inspection technologies, suffers from a lack of a topic sentence, and also suffers from a lack of synthesis, which we will continue to address in *faux pas* 4, as there is no interpretation of the connections between the articles. Without an umbrella sentence, and without linking words, the reader must read the mind of the author to try to figure out what is important.

Ineffective Topic Sentence Example 2

Kawaguchi developed a robot with dual magnetic wheels for internal iron pipe inspection. This system was compact enough to avoid occupying most of the pipe cross-section, allowing it to travel in any orientation through the pipe to avoid valves or plugs.[7] Yanqiong's design of a modular mobile robot with magnetic wheels showed the benefits of a modular robot design in inspection missions. This design is capable of traversing a cylindrical surface to detect weld seams.[8] Ariga et al.'s inspection robot can climb the narrow space between walls using a pantograph mechanism and springs.[9] Sekhar designed a duct fan-based wall climbing robot for concrete surface inspection.[10]

In the revision for this excerpt, the author signposted throughout the literature review, showing the main challenges that the field faces. Before this, he discussed a primary challenge, but incorporated the topics from the prior excerpt into the secondary challenge. The topic sentence alerts us to thinking about a new challenge, and we now expect that the paragraph discusses these challenges. Further, the author decided that the overarching conversation and reasons for citing these examples was that each of these examples of systems developed to inspect hazardous environments had limitations that his study sought to mediate. As such, he decided to not spend specific space calling out each one of the articles, instead, using the studies to meet his needs rather than getting lost in the weeds.

Ineffective Topic Sentence Example 2: Revision

The secondary challenge in inspecting DCSSs is finding a way to navigate a highly confined and hazardous environment. Thermal conditions inside the structure are well above 250 °F.[6] The use of mobile robotic devices for inspection of hazardous environments is supported by Leon-Rodriguez et al.[7] They found robotic deployment of non-destructive inspection is the only means of testing in hazardous and dangerous environments. The task of navigating confined or hard to access spaces has been approached in varying capacities by many robotics researchers.[8-14] However, many of these researchers did not quantify the uncertainties or causes for positioning error in the system after successfully validating the system functionality.

9.2 Fluffy Writing

Be careful of fluffy writing and excessive wordiness: in other words, avoid phrases and sentences that do not really mean anything at all. You can think of excessive wordiness being like empty calories: like the calories in donuts or cotton candy, they take up space but offer no nutritional value. Rather, think about how each sentence can be revised to take up as little room as possible, while preserving the important relationships. You can still have complex thoughts and compound sentences; however, ensure that your sentences are as clear as possible.

Eliminating fluff also means getting rid of excessively wordy alternatives to more direct words. One of the most prevalent examples is the tendency of engineers to overuse the word *utilize* (and its derivatives) [1]. It is much simpler to just write *use*. Remember, the rigor of your topic and disciplinary expertise will come through and will be highlighted with the use of direct and concise language. Using overly fluffy language works in the opposite way, because those phrases are ones that high school students often use to sound smart. Instead, you will show your smarts in other ways, such as through writing a tight and well-written literature review, not through using excessively wordy sentences.

There are many examples of fluffy writing through our other examples in this chapter; as such, we leave it to you to find those offenses in the original examples. Note how the language is condensed in the revision excerpts. Unfortunately, this is a book on literature reviews, not a book on revision. We refer readers out to other literature for help in revising for clarity and conciseness; one of our favorites is Michael Alley's *The Craft of Scientific Writing* [1].

9.3 Globalisms

Because writing a literature review is hard, in the initial stages, most writers feel compelled to write overarching motivation statements. These grandiose statements usually include some fluff and read like something that a narrator says in a movie trailer. We present some real examples of globalisms in action, along with revisions and our comments on the examples.

If you find yourself using globalisms to get into the paragraph, we do not mean to shame you. When you are composing, just let yourself write. Go back later to examine the first sentences in a paragraph to discern if they are too broad – often, the second or third sentence is a much tighter umbrella sentence, and you can negotiate with the paragraph to start at a more effective level.

In this first example, this author seeks to introduce the topic of biomimetic design. However, in the original example, the motivation mistakenly starts with a definition of robotics, which is off-base for a scholarly article that will be published in a robotics journal. Further, there are fluffy words that do not add value to the motivation in the second sentence, such as the arbitrary claim that the advancement of the field is becoming more tangible and impressive.

Globalism Example 1
Robotics is a field of study that is highly applicable to other disciplines like biomimetics and controls. As this field advances, its capacity to affect everyday life is more tangible and impressive.

In contrast, the revision of this excerpt uses citations to document claims, and the language is both expanded in terms of specific details yet culled to include only meaningful words and phrases. You will note that the goals of the introduction statement remain the same: to introduce biomimetic design and purport that the discipline is growing. In the revised motivation, the author makes a much more compelling claim by better honing the motivation and removing the globalisms.

Globalism Example 1: Revision
Biomimetic design is a concept generation process that uses biological systems to inspire other mechanical systems. The use of biomimicry is important to advance robotic abilities, ultimately affecting systems related to defense,[1-2] transportation,[6,9-12] and risk mitigations.[8,16,23] Biomimetic design has become an increasingly significant part of the robotic field in the past 10 years.[9,15,21]

The second example of globalism, from a paper exploring Particle Image Velocimetry as a flow visualization technique, starts by musing about curiosity as a human condition. It has nothing to do with turbulent flow diagnostics.

Globalism Example 2
Curiosity is at the very base of humanity and it is what makes us so different from other animals. People have been constantly developing techniques to quench this curiosity of understanding nature and its consequences. Image analysis and post-processing of data enables us to better understand the various fluid flows that occur in nature. 3D visualization of these flows open up many new possibilities. The need for studying new imaging techniques has been growing in the recent past with the advances in hardware and fast growing technology.

Instead, in the revised version, the first sentence introduces some of the complexities in studying turbulent flow before immediately narrowing down to the importance of flow visualization techniques, without any posturing about human nature involved. This revised version is obviously more acceptable to an expert scholarly community.

Globalism Example 2: Revision
Despite being studied for centuries, turbulent flows continue to be poorly understood, as they are very complex, three-dimensional, and are impossible to understand with the naked eye. Hence, researchers need tools and techniques to visualize these flows in three dimensions to investigate the underlying physics. Therefore, the need to develop new imaging techniques has been growing in the recent past with advances in hardware and fast-growing technology.

There are a couple of strategies to remedy globalisms. The first is to dig into the paragraph until you find a sentence that has specific content in it, and ask yourself if that is actually the topic sentence. In the Globalism Example 2, the author has dug to sentence 3 before there is content that relates to fluid flow and image analysis, and revises it and the subsequent sentence to be more effective. The next strategy is that – since globalisms tend to occur at the beginning of a literature review – your first sentence of your paper should specifically address the phenomenon or topic about which you are communicating. The first sentences of a literature review set your readers up to understand the scope of the literature review overall, and subsequently, your work.

9.4 Lack of Connection or Synthesis Between Topics or Articles

An effective literature review should make sense even to people who have not read the articles that you have read. Therefore, your job is to show the connections between the articles rather than asking your reader to surmise the connection between the articles you cite.

Here is an example of an excerpt that lacks synthesis. The original version is difficult to read because the author jumps between specific pieces of information without linking them together. Further, some of the sentences are vaguely related to each other, and without the author telling us what the links are, we as readers are left feeling discombobulated and frustrated. Last, the specific details given about each study drag the reader down, especially because this is the first

paragraph of the literature review that is supposed to give an overview of the research for the reader.

Lack of Connection or Synthesis Example 1

Highly-evolved flying insects such as flies and wasps have achieved superior flight stability and agility, wide range of flight envelopes and miniature body size that no human-engineered systems can replicate. By using applied magnetic torque on fruit flies with tethered ferrous pin, researchers were able to record fast recovery of in 2.5 wing beats.[1] The fast sensory feedback required to maintain stable flight was discovered to react with each wing beat.[2] Dragonflies can also use predictions to intercept prey.[3] Researchers also reported a record of male *Hybomitra hinei wrighti (Diptera: Tabanidae)* reaching top flight speed of 145 km h^{-1} in pursuit of females.[4] The studies on insect flight lead to variety of bio-inspired design that provide great improvement to man-made machines. For example, research in the hawkmoth abdomen movement motivated a smart design to use battery to counterbalance disturbance in quadrotors.[5]

In the revised version, the author remembers that in this introductory paragraph, his job was to introduce the motivation and broader landscape of the literature at this point before using the remainder of the literature review to go into more specifics. This is a much more approachable and digestible paragraph, and it shows the reader what she or he should be inferring from the references.

Lack of Connection or Synthesis Example 1: Revision

Highly-evolved flying insects such as flies and wasps have achieved superior flight stability and agility, wide range of flight envelops and miniature body size that no human-engineered systems can replicate,[1–7] and therefore have motivated research studies from both engineering and biology research communities in the past decades. These studies range from experiments and simulations of flapping wing aerodynamics,[8–11] flight dynamics,[12–17] and neural sensing and control of flight.[8–21] While most studies center on the hovering flight in either tethered or free flight conditions, forward flight has received relatively less research attention. Forward flight is interesting because most insects fly at a broad range of speeds (fastest record: Male horse fly, 145 km (h^{-1})[22]) during foraging, chasing mates and escaping from predators.[23–25]

While the original version of Example 1 suffered from lack of flow in terms of details, topics, and scope, the following example shows a paragraph that suffers from a lack of synthesis. This paragraph "reports out" but does not synthesize, leaving the reader jumping between pieces of information from various articles without understanding how they connect or relate to each other. One of the reasons that the relationships are unclear is that there are few linking words showing those connections. Further, most of the sentences take the same direct structure, leading to a lack of rhythm. Some sentences are unclear, such as the mention of "these years" or what the "rigorous derivation" in sentence 2 has to do with the Monte Carlo simulations in the surrounding sentences, especially since they are all from different sources.

Lack of Connection or Synthesis Example 2

The fission matrix is proposed as an acceleration method of the standard Monte Carlo simulation.[1] A rigorous derivation of the forward and adjoint fission matrix is given.[2] The stability and the convergence problem of the fission matrix based Monte Carlo criticality calculation has been studied these years.[3,4] The fission matrix based Monte Carlo calculation has been proved to calculate the power distribution accurately in an advanced reactor model.[5] Moreover, it is shown that the fission matrix can accelerate the standard Monte Carlo criticality calculation greatly and a fission matrix based Monte Carlo simulation can be applied on a spent fuel model.[6] In addition, the fission matrix also could provide the higher eigenmodes of a reactor and it has been examined on a numerical model.[7]

In the revision process, this student was encouraged to focus on the flow between ideas and why in particular each article was being employed in the literature review. The resulting corresponding paragraphs work to integrate the necessary parts of the theoretical background, embeds some sneaky definitions in terms of equations, and synthesizes the past applications of the fission matrix for the readers.

Lack of Connection or Synthesis Example 2: Revision

The fission matrix was proposed as an acceleration method of the standard Monte Carlo simulation,[1] for which a rigorous derivation of the fission matrix theory is given by Carney.[2] The criticality eigenvalue problem could be expressed in fission matrix form as

(*Continued*)

Lack of Connection or Synthesis Example 2: Revision (Continued)

$$\vec{F} = \frac{1}{k} \cdot \boldsymbol{A} \cdot \vec{F}$$

Where $\vec{F}$ is the source distribution and *k* is the multiplication factor. The fission matrix coefficient *A_ij* is defined as the fission neutrons born in cell *i* per source neutron from cell *j*. It can be inferred that the fundamental eigenvalue of the fission matrix equals to the multiplication factor and the fundamental eigenvector equals to the source distribution.

The fission matrix method has seen an increase in popularity in recent years, for several applications. For example, the fission matrix has been used for evaluating and accelerating the convergence of Monte Carlo criticality problems,[1–5] evaluation of higher order eigenvectors,[6] and solution of transient problems.[7–8] The transient fission matrix work is of interest here because they use a similar method of combining fission matrices that were calculated under different conditions to estimate the "real" fission matrix.

These are the four main issues that require revision for graduate students during the revision phase. You will see elements of things we already discussed, such as topic sentences, synthesizing literature using linking words, and using a variety of different kinds of citations depending on how you are using a given piece of literature. Grammar, spelling, and formatting (especially formatting references) are also an important part of the revision and editing process at this stage, adding to readability. We nod here to the importance of these issues and propose that there are many fantastic resources that can get into these issues. If you would like resource suggestions, Chapter 12 includes a reference guide to other texts that will help you continue to hone your writing abilities.

Reference

1 Alley, M. (2018). *The Craft of Scientific Writing*, 4e. New York: Springer.

10

Am I Done Yet?

The absolute worst thing about writing literature reviews is that it is impossible to be *done*. Even if you were to exhaustively collect, read, synthesize, and write about all the literature related to a particular topic area, in the time that you would spend doing that, you can be sure that other groups will have published something new in the area! So, when can you be done with your literature review?

10.1 Self-Check Yourself Before You Wreck Yourself

There are several constraints that will guide you as you develop the sense of when you can stop writing a literature review. A good literature review will check all these boxes and you can happily submit your draft.

Self-check 1. Length and density of citations are on par with others in the desired venue. If you are writing a conference paper with an eight-page limit, then you should not be spending more than a page on your literature review: you should be devoting the majority of your allocated space to your methods and findings. Your literature review in this case will be short and will review the literature most closely related to your research questions. The inverted triangle for your literature review will start more narrowly than a longer literature review. If you have cited the most relevant papers from research teams who do related work to yours, then the next thing to check is the density of citations. Your paper should have a similar number of citations as other publications in the venue, and the number of citations per paragraph should mimic that of other publications in the venue. This is something that is easily checked.

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Checklist items:

- My literature review is about as long as other literature reviews found in publications from this venue.
- My literature review has approximately as many citations as other literature reviews found in publications from this venue.
- The density of my literature, and the way I use my literature, is similar to the ways other literature reviews published in this venue are used.
- My literature review mimics the normative style of literature reviews found in this venue.

Self-check 2. The reader is effectively prepared to appreciate your results. A literature review is complete when the reader feels that your research questions are relevant and important, and that they then can appreciate your results. The best part of having checked this box is that it is quite easy to write the discussion and conclusions sections, because you will clearly have shown yourself and your reader how your results advance the body of knowledge and fit into important discussions in your disciplinary community.

Checklist items:

- My literature review follows a logical pattern and leads the reader to the research purpose or research questions.
- My literature review cites the most relevant literature and synthesizes similar works together in a way that establishes the gap in the literature that is filled by the research questions.
- It is clear that the problem is important and that no research group has completely answered the questions associated with this problem.

Self-check 3. Any new piece of literature that is relevant to my project could be assigned a logical section or paragraph. Chances are, as you progress through the writing and research project, you will come across new papers that are relevant to your research process. You know you have a robust structure for a literature review, especially a more comprehensive literature review such as one required for a thesis or dissertation, when you have a section or paragraph where any newly found (relevant) paper could fit. For a comprehensive document, you should weave in your newly found relevant papers, but even for shorter documents, it is a good check to see if you have discussed all the topics you need to if you can easily take a related article and are able to say "hypothetically, if I were to cite this article in my review, it would go around *here*."

This is also a great way to strengthen your citation density. Chances are, if you come across a related paper, you may be able to include it in a string citation to

indicate that there are a variety of researchers working in a given field. Again, though, most venues require a review of relevant literature and not a comprehensive literature review.

Checklist items:

- Any new papers I find that are closely related to my research questions could find a home in my literature review structure if I were to incorporate them (even if it would mean building out a new paragraph in a section).
- If the paper is relevant, I have woven it into the literature review.

Self-check 4. The topics I discuss cover the major conversations discussed in other literature reviews. As you get deeper into the literature surrounding your project, you will be able to read literature reviews with different levels of understanding, because you, too, will have read most of the articles. Therefore, you will know when you are near the end of the literature review-writing process because you will no longer encounter any conversations in the literature reviews of the published literature that make you say "Ohhh, I should really talk about that." You will already have dedicated a section to it.

Checklist items:

- I am citing the leading scholars in the field that everyone expects to be cited.
- I cover the relevant recent conversations in the field that are related to my topic.

Self-check 5. My literature review is formatted in a consistent manner, and I have done my best to clean up spelling, grammar, and other writing issues. Regardless of if your literature is in the correct order, if the sentences do not make sense, are overly wordy, or are not grammatically correct, the reader (including your advisor) will have trouble digesting and appreciating your argument. Before being *done* with a literature review – even at the draft stage when you will turn it over to your research advisor – it is important to make it as strong as possible, so that readers can spend time thinking about your thoughts rather than getting frustrated with mechanics. Spending extra time editing and revising for the "Big Four" literature review faux pas (Chapter 9), getting a friend to read and mark up your draft, and reading your literature review aloud will all help you make as tidy a draft as possible. Remember, the draft that you submit to your advisor should also be your best draft (and definitely not a first draft). It goes without saying, too, that your citations in the reference section should be formatted correctly and included in the literature review draft.

Checklist items:

- I have revised my document to take care of the Big Four literature review faux pas (Chapter 9).
- I have asked a friend to read and mark up my document to identify unclear writing and areas for improvement.
- I have read over my document OUT LOUD and it flows naturally, sounding like a scholarly literature review found in other published works.

11

Interpreting Advisor Feedback

The relationship between an advisor and a student may come most at odds with one another during the writing process. An advisor's primary role is to guide and direct the scope of the advisee's research, because the advisor is the subject matter expert. This primary role is a great benefit to the advisee because the advisee should able to interact, ask questions, and find advice on solving problems. This is the function of the teacher–student relationship. The second role of the advisor, however, is often less apparent and less outwardly enjoyable for the advisee: universities, colleges, departments, and faculty in the academy must maintain a standard of excellence and teach their students to uphold and represent that reputation. This role manifests in a seemingly endless series of revisions.

No student has ever escaped unscathed from a critique of a manuscript, and the intricacies of the advisor–advisee relationship tend to compound the uncertainties that come with academic writing. In the optimal scenario, an advisor will be communicative and transparent in articulating what they expect in high-quality academic writing, such as, "Great job connecting the literature with your research in compelling ways." However, advisors can be particularly bad about commenting on the good parts of writing ... focusing on the necessary improvements and will at best write, "Good!" or something to that effect. Alternatively, if you have comments on your paper, which read (in the nicest case), "I see where you are headed with this line of reasoning, but you need to cite literature to support this claim," then you know your advisor is acting out the secondary role to maintain quality. (Other translations of this comment include: "Need citations!" "Expand this statement" or "Build this out!" or "So what?")

While receiving feedback, criticism, and reviews – which generally focus on the negatives and things that need changing – absolutely stinks, the reality is that everyone who reads and comments on your writing is investing time in both you and

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Table 11.1 Translation table to interpret vague feedback on your literature review or other scholarly writing.

If your advisor writes ...	They might really mean ...	Which means you should work on ...
"So what?" "And so?" "Expand" "Build this out"	You have not effectively translated the relevant part of the literature into your literature review and connected it with other literature in a way that is compelling.	Answer the question "So what does this mean?" or "Why am I talking about this?" The answers to these questions should be incorporated into your discussion of that particular source or statement, as a way of expanding and justifying your argument. Remember, you cannot expect your audience to naturally jump to the conclusions or importance that you are giving to a particular statement. They are not in your mind, so you need to articulate the importance of your statements and the connections between the literature.
"Unclear" "Ambiguous" "I don't understand" "?????"	The sentence/paragraph is too wordy to make immediate sense of this and I cannot follow it so I have stopped reading this sentence/paragraph – or – I cannot tell how this relates to the overall paragraph (or literature review overall).	Ask yourself to paraphrase. If you need to, talk it through with your friend to find an unambiguous and concise way to say what you really mean. Look for words and phrases to cut out that do not add value. Keep the details that are important, and ruthlessly cut words and details that do not add value to your work.
"Choppy" "Awkward" "Unclear"	There are not clear links between sentences, between ideas, or between paragraphs.	Ensure that each paragraph has a clear topic sentence that acts as an umbrella to cover the ideas in that paragraph. Ensure each sentence flows together: read it aloud if you are unsure if it flows. Ensure you are using appropriate linking words to compare and contrast literature. Edit each sentence to be as unambiguous as possible.

the quality of the work. All reviews work toward making the written document stronger and more compelling, and over time you will learn to take reviews slightly less personally than at the beginning. But writing is a personal activity, as we discussed at the beginning of this workbook, so it will always feel like a review of your writing is a review of yourself as a person.

There are a few strategies for handling comments (either from your advisor or from reviewers). The first is to read them, then put them in a drawer before proceeding through the stages of grief. This takes some time, if you can afford it. However, if healing time is not part of the equation, then you must learn to swallow your pride and determine how to translate the comments written in the margins into writing issues that can then be addressed. While some advisors may be good at identifying where writing issues lie, others are really not, and will simply write "improve" or "revise." While this is unfortunate, we have compiled a translation guide (Table 11.1) to discern (or at least lead you to) some strategies for revising areas of your literature review that get marked up with little or no explanation.

11.1 Conclusion: Our Wishes for You

Congratulations! You have worked through this book, accomplished a great deal, and likely know more about both writing and your research topic than you did when you began. We support you in all your future research and writing endeavors and want to encourage you with this reminder: your first literature review is by far the hardest – it will only be easier from here.

Our best,
Catherine and Joshua

12

Theory Behind the Practice

For Instructors and Advisors

In order to engage students from the outset, we made the deliberate decision to forgo a more standard scholarly chapter at the beginning of this workbook. This decision was made firstly because textbooks written for other instructors tend to turn off students (our target audience) who are simply looking to be told what to write, how to write, and/or how many sources they *need* to include in their literature reviews. Secondly, given the constraints of a workbook of this nature, we did not want to rehash all the great work and resources that has already occurred on technical writing and literature reviews elsewhere. This chapter is designed with the idea of pointing you, the instructor, to some of the theoretical and practical work that already exists on these topics. These recommendations are not exhaustive; rather, they are texts that we find ourselves often assigning in class, recommending to students, or referencing ourselves when presented with particularly troublesome questions.

Our hope in writing this workbook is to make each (sometimes painful) step of the literature review transparent, with an honest account of what parts are difficult for novice writers and researchers. We have designed activities through a constructivist educational lens along the way to help students mature in their own confidence in manipulating academic engineering literature, and to encourage their appreciation for the pragmatic justifications that experts use in the composition process. Examples of such activities range from familiarizing one's self with articles that are published in a journal that one wishes to publish in to ascertaining the appropriate length of a literature review or determining how many references ought to be cited. Understanding the "breadth" and scope of a literature review at the beginning of a project is a strategy that most novice academic engineering writers are blissfully unaware of, and, subsequently, cause a great deal of consternation once they seek guidance from their advisors. We hope to confront

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some of these issues by helping engineering researchers develop academic literacy [1–3] simultaneously as they gain a broader understanding and depth of knowledge of their new field.

This work is grounded in our own research and teaching expertise in undergraduate and graduate engineering student writing and education, but the paths of how we arrived here have been paved by several different research communities. To this end, we would point instructors and advisors wishing to gain further insight into some of the text that inform this workbook and supplement our own teaching practice to research that draws from the following four disciplinary areas:

1) Genre studies and moves-steps analysis
2) Technical writing for engineers
3) Literature reviews
4) Grammar editing and revision strategies

By design, our workbook is meant to be used in concert with other texts, handouts, and activities that instructors already employ in their classrooms. The activities that we have designed herein work well for students because they distill the various features of the literature review-writing process without distracting students with the academic-ese that often accompanies such works.

We know through our research, and our experiences working with engineering students for many years, that their attitude about writing is a key predictor of their likelihood of success and self-efficacy in their pursuit to achieving their desired career paths. Students' attitudes about writing are fostered in these nascent efforts to professionalize toward the end of their undergraduate programs or near the beginning of a graduate program; in this sense, their future success in a faculty career largely depends on the skills and abilities they develop during this stage. The reality is, though, that an estimated 80% of engineering students earning doctoral degrees go on to pursue careers in industry; nevertheless, the literature is clear that strong writing abilities and the ability to synthesize information and tailor it to a particular audience is a crucial step toward achieving success in both academia and engineering industry [4].

12.1 On Genre Studies and Moves-Steps Analysis

In his memoir on writing and the writing life, one of America's most celebrated authors, Ernest Hemingway, once remarked that "The only kind of writing is rewriting" [5]. This maxim certainly holds true for all writing genres ranging from poetry to particle physics. Students wrestle with the act of writing and really struggle with and balk at criticism they receive in revision requests. The toil that

students experience in the act of writing is felt because of how much effort they put into each draft; the problem is only exacerbated by the fact that what an advisor is looking for or expecting to see is not always clear to the younger writer. Literature reviews, unlike a methods or analysis sections, are what John Swales calls an occluded genre. Occluded genres are those which exist "out of sight" to "outsiders and apprentices"; they function as "essential waystage roles in the administrative and evaluative functioning of the research worlds" [6]. It is often the case that an advisor does not intentionally withhold information from the advisee, but, rather, the younger writer has not yet had the years of experience and knowledge-building in a given subject area which propels them forward in understanding where their research is limited or not far-reaching enough.

Our approach for teaching literature reviews (and really all types of engineering writing) is through a genre lens, where the "rules" of writing are governed by the forms, structures, and expectations of the disciplinary community for which one writes. There are a number of prominent genre theorists; John Swales is one of the early and more influential theorists to have work directly with engineers, and specifically engineers from an English as a Second Language (ESL) background. Much of Swales' research focused on identifying problems that this niche group of students experienced and then proposing specific solutions to address those problems. As a result of Swales' and others' work in the field, genre theory is often regarded as a mediator between the social and cognitive aspects of domain-specific knowledge; it helps writers effectively mediate the "knowing that" and "knowing how" part of expertise knowledge formation. The work we discuss on literature reviews in this workbook is established on a set of rhetorical moves and rhetorical steps common to engineering student research proposals. Once these moves-steps are identified, engineering students can then utilize these principles that act as building blocks by which students construct a literature review in defense of their argument.

The methodological approach we use to teach literature reviews involves working students through a moves-steps genre analysis (as we have eluded to earlier). The basis for this approach started began with John Swales' (1990) "Create a Research Space" moves-steps analysis of research article introductions [7] wherein he categorizes typical moves that students make in the composing process. His list is not meant to be hierarchical. In fact, the best writers tend to use a variety of all the moves and steps, whereas weaker writers tend to use only a few steps over and over again. Swales' approach has been replicated several places elsewhere, such as in Carmen Soler-Monreal's article "A Move-Step Analysis of the Concluding Chapters in Computer Science PhD Theses" wherein she conducts a moves-steps genre analysis of concluding chapters in computer science PhD theses [8] as well as in Joshua Lenart and Catherine Berdanier's "Optimizing a Genre Analysis Framework to Investigate Engineering Literature Reviews"

wherein they chronical "the development and validation of a genre analysis framework as part of an ongoing research study that investigates how graduate engineering students compose literature reviews in an effort to enter into their disciplinary communities" [9].

Other useful texts on genre studies and moves-steps analysis, which are focused specifically on science and engineering writing, include:

1) Charles Bazerman's *Shaping Written Knowledge: The Genre and Activity of the Experimental Article*, which was an early effort in the field to apply rhetoric and genre studies to the human sciences. This text retraces "the history of the experimental article" beginning in the era of early modern science (1655–1800) and then tracks how experimental research articles change, ever so minutely, right up until the present. *Shaping Written Knowledge* is a genre studies primer and is still regarded as one of the better accounts of how objective science is communicated [10].
2) Catherine Berdanier's "Genre Maps as a Method to Visualize Engineering Writing and Argumentation Patterns" [11] and "Linking Engineering Graduate Students' Writing Attitudes with Rhetorical Writing Patterns" [12] both based on her dissertation [13], all study engineering graduate student's attitudes toward writing. In this work, Berdanier conducts a genre analysis of graduate student research proposals that won the National Science Foundation's Graduate Research Fellowship Program.
3) Carol Berkenkotter and Thomas Huckin's *Genre Knowledge in Disciplinary Communication: Cognition/Culture/Power* presents a compelling study on "how readers' search for 'news value' [...] in the changing structural conventions of scientific articles" [14]. This text provides a theoretical backdrop to genre studies, in general, and socio-cognitive writing instruction unique to scientific and technical writing, in particular. Instructors looking to gain a more robust understanding of how genre shapes writing, and in turn how writers are embedded in various discourse communities, will find this a worthwhile text. *Genre Knowledge in Disciplinary Communication* is also useful in helping advisors teach their students how to better identify the discrete structures and governing criteria that they must contend with if they are to become effective, persuasive communicators.
4) Fahimeh Saboori and Mohammad Reza Hashemi's "A Cross-Disciplinary Move Analysis of Research Articles Abstracts" analyzes research article abstracts in the fields of applied linguistics, applied economics, and mechanical engineering [15]. Given the primacy of the research article in academic communities, a thorough analysis of the abstract is particularly relevant because of the way in which abstracts often act as THE determining factor of whether a researcher reads an article. After performing a moves-steps analysis

on a set of abstracts, the study determines that "disciplinary variations" of academic discourse communities "influence the textual organization of the abstract" [15]. Genre analysis, in this example, helps writers improve the likelihood of having their work read.

12.2 On Technical Writing for Engineers

This workbook was born primarily from our teaching positions, which place each of us in the somewhat unique position of teaching engineers how to write. It often occurs when other professionals learn of our chosen profession, that their reaction to this discovery is a bemused mixture of curiosity and sympathy followed by the utterance of some cliché attempt at a joke that evokes both engineers and writing. Recall here the old anecdote that Supreme Court Justice John Robert's once confessed that he quit telling lawyer jokes because lawyers never found them funny, and everyone else believed them to be true. It is not our aim to rehearse old, unhelpful, and often harmful stereotypes about engineers and writing; rather we wish to challenge this prejudice by showcasing some of the excellent work that has occurred in the field of technical writing that draws examples from various engineering disciplines. For their part, we have found many of the engineering students that we have worked with over the years to be some of the most intelligent, articulate, and interesting students we have interacted with in any other class or capacity.

Engineering students do present a unique set of challenges to writing instructors and academic advisors, primarily because the nature of their work is so demanding and because of the analytical, problem-solving approach they use to complete most tasks (whether personal or professional). Beyond simple caricatures, the vast majority of engineering students simply have not been taught by their advisors of the proper ways to undertake the individual components of the research process. This is especially true with literature reviews. For more information on technical writing, and other components of the research process, we recommend checking out the following:

1) Joan van Emden and Lucinda Becker's *Writing for Engineers*, which does not focus on writing literature reviews explicitly; however, it maintains a clear orientation toward writing in engineering disciplines [16]. This readily accessible text provides an overview of typical problems that engineering students encounter, such as grammar, style, tone, vocabulary, punctuation, presentation, and writing for publication. It also suggests revision strategies for trying to publish or for presenting in front of different kinds of audiences. Designed as a quick reference guide, students who prefer a bound text over an electronic one will find this little guide handy.

2) Angelika Hofmann's *Scientific Writing and Communication: Papers, Proposals, and Presentations* is an encyclopedic reference manual that begins with a detailed overview of low-order writing problems like word choice, tense, and paragraph structure and then moves onto higher-order composition considerations such as drafting, avoiding plagiarism, and designing effective tables and graphs [17]. It concludes with a detailed characterization of the various components of a research paper, review article, grant proposal, and poster presentation. The section on writing a research paper mostly neglects the process of compiling and writing a literature review; however, it does contain useful guidance suggestions on writing abstracts, results, and discussion sections, while taking care to describe typical problems that ESL science and engineering students encounter. Designed for mid-career and senior researchers, this text is, perhaps, more costly and too exhaustive for undergraduate and early-career graduate students.
3) David Beers and David McMurrey's *A Guide to Writing as an Engineer*, now in its 5th edition, is an easily accessible guide for undergraduate, Master's level, and first-or second-year PhD students. Focused primarily on workplace writing, this text features helpful sections and activities on writing memoranda, emails, resumes, cover letters, and other common engineering documents such as laboratory reports, proposals, and recommendation reports. This is an especially relevant text for students trying to figure out or just entering into their chosen career fields as the sections on "writing to get a job," "components of ethical writing and reporting," and "managing one's online reputation" are all timely and educational [18].
4) David Kmiec and Bernadette Longo's *The IEEE Guide to Writing in the Engineering and Technical Fields* [19], part of the IEEE Professional Engineering Communication Series, is an accessible follow-up companion to the more historical and sociocultural exposition that Longo retraces in her *Spurious Coin: A History of Science, Management, and Technical Writing* [20]. Similar to other texts of this nature, Kmiec and Longo begin by outlining a rationale for teaching technical writing from a rhetorical approach wherein writers are instructed to first assess the social context, or situatedness, of a communicative act (either written or oral), and then systematically progress through the rhetorical stages of identifying a writer's purpose, the audience's needs, and the genre conditions of that act. The primary difference between Beers and McMurrey's text, which showcases and then analyzes a particular piece of writing like a proposal or a resume, and Kmiec and Longo's text, is that the latter admonishes students to learn to first gain greater comprehension about what they know of a topic before embarking on the process of writing about it. This is a slight but important shift from texts like *A Guide to Writing as an Engineer* that operate in more of a show-and-tell approach of simply asking writers to mimic an

idealized piece of writing. Kmiec and Longo urge writers to discover the underpinnings of what they hope to accomplish in their writing by offering them numerous rhetorical tips, tricks, and strategies for logically organizing one's writing by focusing on specific, nuanced elements of how arguments are structured as well as ascertaining some of the myriad conditions writers must always consider. Particularly useful sections include: "Understanding What Constitutes Sufficient Evidence to Support a Claim," "Designing Your Argument to Consider the Audience's Preexisting Beliefs," and "Assuring Outcomes and Benefits without Seeming Unrealistic" [19].

12.3 On Writing Literature Reviews

While it is difficult for us to imagine that you do not already have everything you already need and already need to know about writing a literature review after having worked through this workbook, there are several other excellent texts on the topic. (Admittedly, we have our biases.)

1) Arlene's Fink's *Conducting Research Literature Reviews: From Internet to Paper* is a feature length textbook with examples drawn primarily from the social, behavioral, and health sciences [21]. From the outset, Fink stresses the importance of proposal writing as it relates to identifying and securing funding in order to sustain research projects and collaborations. From there, Fink launches into a discussion on how to seek out, screen, and supplement online reference sources that students come across in the data-gathering stages of a project. Engineering students will find the later chapters of this text particularly relevant to their writing practice, as the book transitions in its final chapters from a how-to-do-it teaching mode into a less prescriptive, more applied application of synthesizing and meta-analyzing literature once the review nears completion. Fink reminds students of the absolute necessity for ensuring that literature reviews are "systematic, explicit, [comprehensive], and reproducible" to ensure that the writer's efforts are useful for "identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners" [21]. Filled with numerous examples correlating to each topic she explains, this text offers an annotated account of the literature review's various components. That is, it is a text that helps students learn about literature reviews, but does not pressure them to complete writing activities in the process.
2) David Garson's *Guide to Writing Empirical Papers, Theses, and Dissertations* aims to engage students involved in "empirical research, in which the writing process is inextricably bound to research design and statistical methodology"

[22]. Focused primarily on qualitative research, this text contains a comprehensive section on how and where to locate sources within research databases, online journals, and governmental websites. It also features a lengthy, albeit now dated, section on using bibliographic software and reference managers. The real merit of this text is that it collates scholarly reference journals and databases, researcher resources, and grant allocation organizations all under one title. This book will be most useful to researchers who are new to the process of using their research to generate further funding.

3) Paul Oliver's *Succeeding with Your Literature Review: A Handbook for Students* provides a rationale and characterization of the importance of literature reviews in academic writing [23]. Intend for a general, not engineering-specific audience, Oliver argues that at the "undergraduate or Masters levels, the literature review for a dissertation may typically be 2000 or 3000 words in length. A doctoral thesis may often be about 80,000 words long, however, and the literature review at least 20,000 words, and maybe more" [23]. Length of the review, he continues, undoubtedly has numerous impacts on the writer, which include subject selection, length of analysis and synthesis, and usefulness of the review after it is completed [23]. The sections that merit the most relevance for engineering students are the ones on how to identify and organize key words into research themes, how to cautiously critical inadequacies both in the research or the research method, and the one on developing strategies for devoting more time to the most relevant texts in a literature review. Similar to Fink's *Conducting Research Literature Reviews*, Oliver's text may very well be a welcomed supplement to this workbook for those students looking to gain more background on the literature review as a genre.
4) Diana Ridley's *The Literature Review: A Step-by Step Guide for Students* is an industry standard for teaching graduate students how to write literature reviews [24]. While this text is not STEM-specific, advisors, writing instructors, and students alike will benefit from a review of the chapters on "Being Critical" and "Foregrounding Writer Voice," which are themes we touch on in this workbook, but do not flesh out in as comprehensive detail as Ridley's text does. Our rationale for not developing these three areas more fully in this workbook is because these topics are all inherently difficult concepts to teach in the confines of a one-semester course. It is also our belief that students improve in these areas naturally as they mature intellectually and professionally. The final chapter, "A Systematic Literature Review," will be most useful to students nearing the completion of a doctoral literature review. Ridley distinguishes here between a dissertation literature review and a systematic literature review where the former involves "the collection or primary data, e.g. [that which ...] provides context and theoretical underpinnings to the research, evaluates related empirical studies and identifies how the current project extends or fills

a gap in previously reported research in the field" [24]. In contrast, a systematic literature review, Ridley argues, "is in itself a research study, addressing research questions and using the literature as data to be coded, analyzed and synthesized to reach overall conclusions" [24]. Because "[m]any of the techniques and tools [...] are applicable for both sorts of reviews," engineering students and their advisors will gain a better comprehension into how academic work expands, overlaps, and integrates rhizomatically throughout and beyond a particular research discipline or community.

12.4 On Grammar Editing and Revision Strategies

Since the advent of Samuel Johnson's *A Dictionary of the English Language* in 1755 [25] – often referred to as one of the most important texts other than the King James Bible to have influenced the English language – there has been no shortage of reference manuals, style guides, or grammar handbooks all preoccupied with teaching writers how to write. Every good writer undoubtedly has their own preferred favorites when it comes to answering grammar questions. Listed below are some of our favorite grammar guides and articles on revising all of which have lasted the test of time where it concerns style, clarity, and grace.

1) Michael Alley's *The Craft of Scientific Writing* acknowledges from the outset that "[a]s an engineer or scientist, your writing affects not only how much credit you receive for your work but also how much influence your work has. In effect, the quality of your writing influences decisions by other on whether to hire you, to fund your ideas, or to publish your findings" [26]. Alley attributes early career engineers and scientists' difficulty with writing to a "misguided education movement" wherein writing instructors moved from an explicit focus on the rules of grammar and technical usage to more first person, less formal observations of the world surrounding the writer [26]. Distilling the most useful formal-grammar rules that concern a scientist or engineer, this book speaks both to the instructor, on best practices for teaching usage and grammar, as well as to their students, who receive composition guidelines drawn from examples drawn scientific writing. Certainly, this book is a useful companion to any writing-intensive, upper-division undergraduate, or early-stage graduate STEM program.
2) Jean-Luc Doumont's "The Three Laws of Professional Communication" should be regarded as standard reading in any technical communication course [27]. This short article outlines concisely how to approach technical writing from a rhetorical perspective, i.e. ascertaining the audience, purpose, and context of any act in which a writer writes or speaker speaks. Based loosely

on Isaac Asimov's "three laws of robotics" [28], Doumont's thesis maintains that students need only understand and practice three[1] key writing principles to improve their language; any more than this, so the logic goes, "is hard to comprehend and hard to remember" [27]. The article is most applicable to students if it is introduced near the beginning of a semester as a way to frame an easily adaptable structure that applies to nearly any writing situation a student is likely to encounter.

3) George Orwell's "Politics and the English Language" is a dated, though as yet still relevant, treatise on the ills of the English language and ways of preventing what Orwell forewarns will result in an "inevitable" and "general collapse" of civilization should language usage degrade further than it already had, in his estimation, by 1946 [29]. Earmarking several of the more egregious mistakes that writers make, Orwell explains why "dying metaphors," "pretentious diction," and "meaningless words" all hinder a writer's ability to communicate effectively and expediently. Orwell concludes the essay with a list of six tenants all meant to guide novice writers:
   a. "Never use a metaphor, simile, or other figure of speech which you are used to seeing in print.
   b. Never use a long word where a short one will do.
   c. If it is possible to cut a word out, always cut it out.
   d. Never use the passive where you can use the active.
   e. Never use a foreign phrase, a scientific word, or a jargon word if you can think of an everyday English equivalent.
   f. Break any of these rules sooner than say anything outright barbarous" [29]. Because of the relatively short length of "Politics and the English Language," is a useful reading assignment that instructors can assign out of class to generate in-class discussion.
4) The Purdue Online Writing Lab (OWL), hosted by the College of Liberal Arts at Purdue University, maintains one of the finest online reference databases for answering nearly any grammar question that a writer might pose [30]. Housed within the database are myriad tutorials, handouts, and PowerPoints; it even features an online support function. The Purdue OWL is the go-to online reference site for writers ranging from undergraduate students to senior researchers who are searching for quick answers to lingering grammatical questions. The site is most useful for those who have specific questions on specific topics; writers with more general, vague, or exploratory queries will do

1 Disclaimer: Doumont asserts students need only become proficient with three laws, though he admits to sneaking a fourth into his argument – the "Zeroth Law" – which he explains is the binding intent or purpose that guides the other three laws.

better to consult one of the texts described in the Section 12.1, such as Angelika Hofmann's *Scientific Writing and Communication* [17].

5) William Strunk Jr. and E. B. White's *The Elements of Style* is designed to inform writers from virtually any background of common rules of grammar, usage, form, and style [31]. Expressly relevant with ESL students, this handbook is meant to be used by writers who are interested chiefly in the study of language as a personal interest or self-improvement endeavor; regrettably, it is less useful in classroom settings when compared to Williams and Bizup's *Style: Lessons in Clarity and Grace* or Michael Alley's *The Craft of Scientific Writing*. Organized mostly as a list of dos and don'ts, *The Elements of Style* maintains something of a cult following among writer's keen on self-motivated writing instruction; however, the text trends, occasionally, toward verbosity and is less accessible to writers looking for quick fixes. Bear in mind, E. B. White was a prolific author, whose more popular texts – *Charlotte's Web, The Trumpet of the Swan,* and *Once More to the Lake* – are beloved by many. *The Elements of Style* has a penchant for literary flair at times, which will most likely cause a love/hate reaction in those who come into contact with it.
6) Joseph Williams and Joseph Bizup's *Style: Lessons in Clarity and Grace,* now in its 12th edition, stands as one of the most long-running and comprehensive grammar and style guide in academic publishing to date [32]. Based on the simple premise that "[w]riting has consequences" and that "[w]hatever does not bear on those consequences is irrelevant to our task – to help our students become what they want to be" [32], the most recent edition features updated sections on a range of topics, including:

   - Gender-neutral and gender-biased language,
   - Examples of elegant passages,
   - Updated examples and exercises that "soften their explicitly American perspective" in the effort to acknowledge text's global readership, and
   - Enhanced sections on "motivation (Lesson 8)" and "using sources (Appendix 2)" [32].

   The popularity of this book over time attests to its implicit focus on revision, not drafting. Indeed, the book's first lesson distinguishes between these two activities by issuing a warning: "if you think about the principles presented in this book *as you draft*, you may never finishing draft" [32]. We have tried to capture this sentiment echoes throughout our workbook as we have tried to remind students that writing is an iterative process wherein the act of writing helps the writer think, and then think more clearly, and then write more clearly, and so on. Williams and Bizup put it like this:

   Most experienced writers like to get something down on paper or up on a screen as fast as they can. Then as they revise that first draft into something

> clearer, they understand their ideas better. And when they understand their ideas better, they express them more clearly, and the more clearly they express them, the better they understand them ... and so it goes, ending only when they run out of energy, interest, or time [32].

Style: Lessons in Clarity and Grace may not be the best grammar guide oriented toward science and engineering students, but it has taught innumerable people how to writer better, and continues to do so.

12.5 Last Thoughts

As discussed, the texts and resources we describe in this section are not meant to be a comprehensive list. Rather, it is our hope that in streamlining this section with sources that have worked well for us, we are saving the instructor and the student time for not having to cull through a more exhaustive list of resources dedicated to helping students write better. Students do not need a dozen textbooks cluttering up and collecting dust on a corner of their workspace. Instead, they need a solid workbook, accompanied by one, maybe two, good handbooks, coupled with healthy doses of time, deft guidance, and encouragement. Given this mixture, they will be well on their way to becoming masterful writers of their craft. Cheers!

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Index

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