Multimodality, Makerspaces, and the Making of a Maker Pedagogy for Technical Communication and Rhetoric

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Dedication

I dedicate this dissertation to all *makers*—doers, innovators, influencers—for their sustained creativity and aspiration, and the change they bring to this world.

Abstract

This dissertation investigates how students create multimodal solutions to address complex problems via technology-enhanced maker practices informed by design thinking. It contributes to the ongoing scholarly conversations around multimodality and multimodal composition by understanding the new material affordances of rapid prototyping technology and dedicated spaces for collaborative invention, fondly known as makerspaces. By investigating how students compose and create multimodal artifacts through making and design thinking, this project identifies useful pedagogical intersections between the Maker Movement proper and technical and professional communication (TPC). To do so, I studied the use and operation of three academic makerspaces in the U.S. at the Georgia Institute of Technology, Case Western Reserve University, and the University of Minnesota. I then conducted a case study of a maker framework based on the findings from the makerspace ethnography. The deployment of the framework—tentatively known as maker pedagogy—occurred in a TPC course. Combining the results from my makerspace ethnography and the pedagogical case study, I discuss the implications of a maker pedagogy for TPC, including the cultivation of a maker mindset, disruption to conventional ideologies, and an exploration of the material dimension of writing. I also discuss ways in which making and design thinking can be assessed in the context of TPC pedagogy.

Table of Contents

List of Tables

List of Figures

CHAPTER 1

Introduction

This opening chapter introduces the exigence to my research in expanding technical and professional communication (TPC) pedagogy approaches by investigating the possibility of augmenting TPC courses with design thinking, multimodal composing, and maker culture practices. I begin by reviewing problems we face in TPC pedagogy today in terms of innovation and problem solving, followed by a synthesis of recent discussions on the need for TPC pedagogy to turn to "making" as a new literacy for rising technical communicators. I close with an overview of the chapters in this dissertation.

1.1 Keeping up with change

The consistent narratives in the academic discipline of technical and professional communication urge scholars to respond to the evolving nature of TPC work and practices, tools and technologies, values and cultures (Johnson-Eilola, 1996; Spilka, 2002; Bekins & Williams, 2006; Hailey, Cox, & Loader, 2010; Zhang & Kitalong, 2015). Looking at one of the cores of our pedagogy, Joanna Wolfe (2009) shows us that most technical communication textbooks today have not kept up with the emergent and changing needs of specific workplaces. The rhetoric we employ is often insufficient and behind industry trends or market needs[1]. While we strive to prepare students to become rhetorically savvy and effective problem solvers of technical communication problems (Johnson-Eilola & Selber, 2013; Wickman, 2014), we still lack solid schemes for teaching students to be creative problem solvers in an age of inconsistent challenges and ever-advancing technologies. We must prepare our students to be ready to face

[1] Fortunately, this is starting to change. At the time of this writing, the textbook adopted by the University of Minnesota Department of Writing Studies for WRIT 3562W Technical and Professional Writing was Richard Johnson-Sheehan's *Technical Communication Today* (sixth edition, 2018), which includes a few discussions of entrepreneurship for technical communicators.

unprecedented issues that require innovative thinking and actions, as Linn Bekins and Sean Williams (2006) and David Hailey, Matthew Cox, and Emily Loader (2010) have contended:

> The creative economy has affected technical and professional communication curricula, students, and alumni in ways that have increased the emphasis on technological aptitude, an ability to work with multiple cultures and numerous independent contractors, to deal with changing expectations, and to manage creative, dynamic, and often nonlinear projects. (Bekins & Williams, 2006, p. 294)

> We further suggest that technical communicators who consistently identify and solve important corporate problems and who develop innovations that positively impact the corporation's bottom line will be more valued than those who write well but contribute nothing more. (Hailey, Cox, & Loader, 2010, p. 139)

Indeed, to correspond with the current intricacies of technical communication and its constituents, TPC pedagogies should reflect an ability to expose students to identify and define complex problems in professional settings, and to devise rhetorical strategies for generating, organizing, and delivering viable solutions. To this end, Jennifer Bay, Richard Johnson-Sheehan and Devon Cook (2018) argue that TPC programs must respond to the changing dynamics of the workplace. Building from recent scholarship on entrepreneurship in technical and professional communication, they recommend incorporating *design thinking* concepts as a rhetorical approach for supporting an entrepreneurship model:

> Today, we need to teach students how to be more creative, empathize with users, reframe problems, pitch their ideas, work in agile teams, and market new products and services to participate fully in the entrepreneurial economy. (Bay et al., 2018, p. 173)

Bay et al. (2018) argue that "a pedagogy of entrepreneurship, via specific techniques like design thinking in experiential contexts" can help students "inhabit the thinking processes of entrepreneurs through real-world projects" (p. 174). Their argument is preceded by several innovative pedagogues who also advocate for non-traditional pedagogies such as "critical-creative tinkering" (Koupf, 2017) and purposeful "making" (Breaux, 2017) in TPC and writing instruction writ large.

As Bay et al. declare, "we cannot afford to continue teaching traditional forms of technical communication to our students" (2018, p. 193). Technical communication scholars like Steven Fraiberg (2017) and Toni Ferro and Mark Zachry (2014) also agree that we need to expand the knowledge boundaries of technical communication pedagogy to embrace industry evolution as well as emerging approaches. Yet, while they recommend big-picture programmatic approaches and a few examples to making entrepreneurial connections to TPC curriculum, little has been done to demonstrate a case-based investigation of design thinking application in an actual TPC course. We need more classroom examples for the deployment of design thinking in order to assess its value and viability.

As such, this dissertation project seeks to contribute to the growing scholarship around design thinking application in TPC pedagogies by providing a pedagogical case study of design thinking in a TPC course. This study is seen through the lens of multimodality and maker practices. The primary goal of this project is to put theory into practice, allowing readers from our field to see how design thinking philosophies and practices might fit in our ongoing conversations of active learning, rhetorical invention, creative problem solving, and emergent literacies. Secondarily, I aim to show readers the ins and outs of design thinking application in an actual TPC course by revealing my process of such integration so they could replicate such an attempt and scale it to their own institutional contexts and requirements.

1.2 But, why making?

> *Our field's DNA is in making—you may hear "maker movement" and think of 3D printing, but think further back to desktop publishing and networked pedagogy and what those things did for writing. — Joyce Locke Carter (2016, p. 391)*

"Making," as popularized by a recent development called the Maker Movement (which I shall discuss further in a later section in this chapter), is beginning to enter the field of technical and professional communication. Within computers and writing—a subfield of writing studies that has tremendous influence on TPC—"making" was the subject of the 2013 Computers and Writing conference keynote by James Paul Gee, and continues to manifest itself in conference programs, journal articles, and books. The Digital Media and Composition (DMAC) Institute at The Ohio State University is taking up the terms "making" and "makerspaces" to embody the kind of professional development it offers for the computers and writing community (McGrath & Guglielmo, 2015). More recently, Chet Breaux (2017) observes that many writing scholars are already very interested in the practices used by makers and the artifacts they create even though the terms "maker" and "making" were popularized only recently. Amid differing threads of discussions and converging interests, I see an opportunity to create a space for interpreting "making" and TPC together through existing theories of multimodality, multiliteracies, and the newer idea of design thinking—to create a case for meaningful making in TPC pedagogy.

Besides the rationale proposed by Breaux (2017), this dissertation is also largely inspired by a Chair's Address, "Making. Disrupting. Innovating" delivered by Joyce Locke Carter at the 2016 Conference on College Composition and Communication (CCCC) in Houston, Texas. Using real-time voice sensing, motion tracking, and corresponding visual displays, Carter performed a sensational address that demonstrated a potential future for multimodal rhetoric that involves not just textual or auditorial appeals but also imagerial and gestural. Besides its demonstrative effects, Carter's address calls writing studies scholars into valuing *making* as a valid and plausible way of learning anything in the 21st century, including writing. Carter's exigence is built upon the historical impact that making has on our field and its advancement. She calls our attention to several innovative instances, such as Daedalus, ELI Review, BABEL, and EyeGuide, all of which have helped define writing studies as a productive discipline that contributes to the betterment of our knowledge society.

> When I talk about making, I'm flipping the power and flipping the epistemology, and saying that when you make, you dictate what will happen. You create new things that hopefully challenge the status quo (which is also the goal of advocacy), and while some, if not most, efforts end in failure, some will be quite disruptive. (Carter, 2016, p. 390)

> And when you hear one of your colleagues say the words "my startup company," or "my new app," you might be tempted to think, "Oh, that's a bit unusual for someone at the C's to talk like this." I'll argue that that kind of statement at the bar, or in a session, should be seen as desirable and normal—as normal as someone who mentions "my new book," or "my research" or "my advocacy." (Carter, 2016, p. 391)

While Carter's address begs for more litigable theoretical frameworks for making, disrupting, and innovating in writing studies, her contention for a multimodal future of writing is well taken and can be used as a springboard to research that investigates multimodal, design-driven, and problem-based TPC pedagogy.

Along with Carter's motivation, this dissertation responds to our field's growing needs for viable pedagogical frameworks to integrate multimodal composition and design thinking with TPC programs. This work particularly subscribes to a characterization of our field that Johndan Johnson-Eilola and Stuart Selber (2013) set out for technical communication:

> technical communicators do not merely learn skills; they must also learn how to learn new skills, upgrading and augmenting their abilities as they mature in careers, analyzing the matches and mismatches between what they currently know

> and what a communication situation demands…[They] must learn to become reflective problem solvers. (p. 3)

Johnson-Eilola and Selber consider problem-solving as a productive characterization for it acknowledges the extent to which our field contributes to technological development and its use, the interpretation of rhetorical situations, and the design of viable solutions based on context, complexity of the tasks and their characteristics. With Johnson-Eilola and Selber's characterization, I am determined to address the core question Carrie Leverenz (2014) asks about multimodal writing instruction, "How can we teach writing so that students learn to use words and other language resources to define and respond in creative ways to problems they see as important?" (p. 4). I aim to take this challenge a notch higher by asking how we might deliver TPC instruction such that writing becomes the "head fake[2]" (to channel Randy Pausch) in the learning process, so that other desirable traits—like greater rhetorical awareness, collaboration skills, critical thinking, ethical decision making, etc.—might emerge as the learning outcomes. To start, I turn to recent narratives that identify the "problems" we face in teaching TPC today.

1.3 Addressing (wicked) problems in TPC pedagogy

As I have forecasted in the opening of this chapter, TPC pedagogy faces challenges in staying relevant to industry trends and market needs, resulting in a need for the field to reinvigorate its pedagogical frameworks to include current methodologies and philosophies such as design thinking in TPC programs. In this section, I trace the cause to these challenges by looking at our resistance to new technology (mainly out of fear and

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[2] Randy Pausch (2008), in his infamous talk, "The Last Lecture" (and book with the same title), shares the notion of "head fake"—or indirect learning. It refers to a situation where someone believes they are learning about one thing (that they usually are not interested in), but are really learning about something different and beneficial to them. A head-fake example that Pausch shared in his talk was youth sports: Parents don't usually care much about their children learning the intricacies of the sports they play, but instead they want them to learn about desirable values like teamwork, perseverance, and sportsmanship.

discomfort), the rise of multimodal composing tools, and the "wicked" difficulty in delivering multimodality in TPC courses.

Any envisioning of a future TPC instruction needs to recognize a major shift in how we compose and consume texts in this age of information technology. Through advancing web platforms, social media, analog and augmented realities, and other virtual interactive tools, writers are moving beyond using just alphabetic texts to access information and communicate with others. Yet, in our writing classrooms, many instructors still resist teaching with new technology for various reasons (Hickey, 2000; Hart-Davidson et al., 2005; Kemp, 2005; Knievel, 2006; Hewett, 2015). In TPC, we still question whether we should teach technology (Garrison, 2018). Bonita Selting (2002) addressed this question by surveying ATTW members regarding their roles as teachers of technical writing in relation to demands to also teach technology skills, concluding that "technological determinism—shown by a tendency to turn a technical communication course into a software tools course—can be seen as a threat to effective teaching of complex workplace rhetoric" (p. 251). In addition, our discipline often aligns with a view reticent toward teaching tools: Reporting on behalf of the College Composition and Communication Conference Committee for Effective Practices in OWI [Online Writing Instruction], Beth Hewett (2015) shared OWI Principle 2: "An online writing course should focus on writing and not on technology orientation or teaching students how to use learning and other technologies" (p. 45).

Such resistance has led to challenges in infusing up-to-date tools and digital/new literacies into writing instruction, including understanding and producing multimodal texts. Aaron Doering, Richard Beach, and David O'Brien (2007) argue that given the ready access to Web 2.0 tools and worldwide audiences, we need to infuse multimodal and digital literacies into writing instruction so students could learn to use media tools to "effectively attract, engage, and influence their audiences," and "foster constructivist, inquiry based learning related to fostering critical thinking" as well as promote effective writing/communication practices (pp. 41-42). Karl Stolley in his "Lo-Fi Manifesto" (2008, 2016) encourages writing instructors to assume such responsibility:

> Those who teach have an even more pressing responsibility to learn and then engage students with digital approaches and technologies that students themselves would not likely discover independently. Students must be afforded the opportunity to write markup, programs, APIs, and commit messages in the same range of learning situations as they write essays and exams today. They must be encouraged, supported, and even joined by their instructors in failed first efforts. The richest learning experiences reveal how failure and crude initial work transform to something better only through ongoing research and revision. (2016, n.p.).

The shift to active use of multimodal composing tools also suggests the need to redefine our notions of teaching writing (e.g., Stolley, 2011). In his *CCC* article, Richard Marback (2009) argues that the concept of design can be appealing to writing studies, particularly for those "teaching writing in digital media" (p. 397), as a way to solve problems that lack a single, knowable solution—otherwise known as the *wicked problem*. A handful of writing studies scholars like Marback (2009), James Purdy (2014) and Leverenz (2014) consider multimodal/multimedia composing as "wicked" tasks that require design thinking as a generative or productive approach to the composing process. While art and design are commonly put in categories separate from texts and literature, Purdy (2014) observes that writing studies programs are, institutionally speaking, moving closer to being associated with design disciplines due to the growing demand to teach information design, writing for new media, and visual rhetoric or communication. Scholars in computers and composition as well as technical and professional communication would agree that traditional writing instruction does not always fit the needs of these new domains. As Scott Graham and Brendon Whalen (2008) demonstrate, "Designing and developing new media communication can be dynamic, creative, intuitive, nonlinear (and sometimes childlike)" (p. 66). This further complicates how writing/composition should be conceptualized and taught, making it harder to define what it is and where the writing problem begins and ends.

Like Leverenz (2014), I consider writing instruction a "wicked problem" beyond its procedural complication (Marback, 2009, p. 400) into how instructors could teach students to move across and beyond linguistic resources to solve communicative problems they identify and consider as important, in innovative and effective ways. Such wickedness requires us to treat the writing classroom not just as a site for information delivery and proficiency testing, or merely a place to practice producing various written genres, but a space for practical guidance—through instructor facilitation and peer support—to solve communicative problems through direct experience with tangible materials. This is particularly important for writing in an information age, where students are equipped with cutting-edge tools and inventive methods that allow them to create content with ease and efficiency. Lisa Dusenberry, Liz Hutter, and Joy Robinson (2015) argue that multimodal pedagogy and assignments are important as they support practices that are considered core characteristics of adaptable communicators. For instructors, this poses new challenges in terms of fostering rhetorical awareness as well as technical knowledge in students such that they are able to utilize all available means of communication to achieve their communicative goals.

Further, several key problems emerge from existing scholarship on the teaching of multimodality. On the topic of invention, for instance, Nathaniel Cordova (2013) finds that multimodal invention is a complex practice due to its convoluted contextual needs—it is "deeply concerned with the hybridity of cultural and the intertextuality of semiotic or symbolic flows, and is explicitly self-conscious about its own contingencies" (p. 150). On the question of (multimodal) writing pedagogy, Carolyn Rude (2009) asks, "What should be the content of our courses and curriculum? How shall we teach students best practices, history, and possibilities? How shall we negotiate competing claims for content and pedagogical methods and compete for academic resources?" (p. 176). For Rude, writing studies programs need to clearly define what is it that we aim to teach across composition and technical and professional communication courses in order to justify our asking of resources to support our pedagogical needs. This includes the question of the place multimodality takes in the writing curriculum—what its significance is and how it might be delivered. On the one hand, Steve Westbrook (2006) points out, "A number of educators have identified the lack of production-based pedagogies as a problem and begun to argue vocally for teaching multimedia composition" (see, for example, George, 2002; Buckingham, 2003; Wysocki et al., 2004). However, on the other hand, "their arguments represent a minority position, for at present a consumer orientation pervades the professional scholarship of the field" (Westbrook, 2006, p. 460).

Apart from these programmatic challenges, our field is concerned with the pragmatics of teaching multimodality. These questions include the issues of consumption and creation, teaching framework, and assessment model, and they serve as the driving force to my research here:

- **The digital divide between consumption and creation:** "We see a divide where students may download complex, multimodal documents but lack the training to understand how to construct similar documents. We see a digital divide where the rhetorics of digital documents become increasingly layered in new technologies and are engaged by one-way reception rather than through true interactivity and collaborative meaning making" (DigiRhet.org, 2006, p. 236). How might TPC courses cultivate a stronger sense of multimodal creation in students?
- **The lack of a pedagogical framework for teaching multimodal composing:** "When teachers in teacher education classes and professional development workshops are faced with integrating images with print and other modes to compose multimodal texts into the context of their schools, impediments arise. Barriers to teacher integration of multimodal composing in schools can range from scripted-lesson classes and rigid curricula, to print-only values and test-prep-only mandates for state graduation exams" (Miller & McVee, 2012, p. 6). How might we best integrate multimodal assignments in TPC courses without being overtly rigid or prescriptive?
- **The lack of a model to evaluate multimodal composition:** "… the assessment of digital and multimodal writing is a challenge for large-scale, standardized assessments" (Eidman-Aadahl et al., 2013). In what ways might we best assess multimodal projects and scholarship?

To address these issues, effective pedagogical frameworks need to be established. By investigating how students might compose and create multimodal artifacts through a makerspace concept inspired by a revitalized technological-industrial revolution called the Maker Movement, I aim to discover how viable makerspaces are for the purposes of multimodal composing—and in the greater scheme of work—for the purposes of rigorous pedagogy in TPC.

1.4 The "multi-" turn

Writing studies had experienced many paradigmatic "turns" in the past few decades. From the early current-traditional instruction (Berlin & Inkster, 1980) to expressivism (Coles, 1967) and process theory (Elbow, 1973; Murray, 1978), to cognitive theory (Flower & Hayes, 1981), to social and advocacy based pedagogy (Miller, 1979; Lay, 1991; Koeber, 2000; Blyler, 2004), our field has undergone these pedagogical paradigms that inform what we see as valuable (and what is not) in the teaching and learning of writing. We agree that writing should not be product-focused but rather emphasize how the writer perceives the writing process (Bartholomae, 1985); we oppose writing instruction that silences the writer's voice (Young, 1990); we argue that writing and thinking are inseparable and thus writers should learn to think critically about writing situations (Dragga, 1997; Scott, Longo, & Wills, 2007); to that end, we advocate for writing as social actions that engage current civic and political tensions within which the writer already resides (Haas, 2012; Agboka & Matveeva, 2018).

Recently, our field has been engaging in conversations about the increased connections between multimodality, multilingualism, and multiliteracies. For example, at the 2014 CCCC, Min-Zhan Lu, Anis Bawarshi, Nancy Bou Ayash, Juan Guerra, Bruce Horner, and Cynthia Selfe (F.38 "Rethinking difference in composing composition") situated the future of writing instruction in translingual, multimodal practices and pedagogies. In this panel, Selfe and Horner (2014) highlighted the importance of moving beyond a "single language/single modality" approach to writing instruction, to account for "the increasing, and increasingly undeniable, traffic among peoples and languages" reflected in our classrooms. Important conversations stemming from this work are reflected in both the NCTE Position Statement on Multimodal Literacies (NCTE, 2005) and the Resolution on Students' Right to their Own Language (NCTE, 1974). In essence, pedagogies that push writing beyond a single-language, single-mode model, and that acknowledge the historical and cultural foundations of linguistic diversity, are increasingly promoted to help students develop rhetorical dexterity to successfully communicate across a wide range of contexts.

Multimodal literacy has also been treated with social considerations of design, power, and action. In his landmark book, *Multiliteracies for a Digital Age*, Stuart Selber (2004) highlights three kinds of technology literacies: functional, critical, and rhetorical. Through a lens of layered literacies similar to that of Kelli Cargile Cook (2002), Selber takes up The New London Group's (1996) term, "multiliteracies," to guide writing instructors and writing program administrators in developing full-scale computer-support composition programs that emphasize his three highlighted literacies. Selber considers technology-driven composing practices from a humanistic perspective, thus putting the pedagogy of multimodality and computer literacy back to the realm of the critical and socio-political. For those with predominantly instrumental views of digital literacy and multimodality, Selber's emphasis of the social scene for computer-based writing offers a contextual view of the composing technology. Most importantly, Selber's "rhetorical literacy" suggests that technical communicators can create new literacies. This opens a new realm of discussion wherein TPC pedagogy might serve as a catalyst for emerging literacy practices, including technological and critical literacies.

Now, I turn to another key exigence for this project following Selber's contention for multiliteracies in the 21st century—that emerging technologies affect how we compose our digital literate lives is a statement worth further deliberation.

1.5 Emerging technologies and new literacies

Every day we read about and find new technologies that are designed to increase productivity and enhance our personal and professional lives. Since the early 70s, writing studies scholars have invested considerable intellectual energy to studying how computer technologies transform communication and inform our pedagogy. Pioneering scholarship, such as Hugh Burns's (1979) dissertation on rhetorical invention through computer-assisted instruction, has focused on the functions and features of computer technologies for composing purposes. Early computer-and-writing perspectives on literacy have also focused on the complications of teaching and learning with technology (Hawisher & Selfe, 1989, 1991; Selfe & Hilligoss, 1994; Sullivan & Dautermann, 1996; Taylor & Ward, 1998). Scholars like Craig Hansen (1996) and Cynthia Haynes (1998) have taken a critical approach to understanding how new computer technologies require new pedagogical theories and praxis in writing and literacy instruction. Gail Hawisher and Cynthia Selfe (1989) have particularly called for greater attention to the kinds of literacies that emerge as a result of the increasing proliferation of networked technologies in the classroom. While studies of browser interfaces, keyboard usage, and even email writing might sound extremely outdated at the time of this writing, they are exemplary cases of innovative research in our field that motivate continued investigations of technology for pedagogical and practical purposes.

The rise of new media and digital technologies continues to capture the attention of literacy scholars. Due to the affordances in pervasive data collection by ubiquitous technologies, we are now studying the politics of these new interfaces in our literate lives, including ideological perspectives (Selfe & Selfe, 1994; Selfe & Hawisher, 2006; Palmquist, 2006) access and intellectual property (Logie, 1998; Fisher & McGeveran, 2007), and surveillance issues. All of this research emphasizes the need for students and teachers to acquire awareness and skills to navigate the new technological terrains.

It is our job as TPC instructors to help students develop such literacy to traverse these terrains. However, we are also tasked with helping students apply these skills to solve real-world problems rather than just talking about them. Given the proliferation of open source applications, rapid-prototyping tools, and computer-powered fabrication technologies (i.e., computer numerically controlled systems, or CNC), how might we utilize the available means for problem-solving to achieve our goals in writing pedagogy––to develop multiliteracies, to cultivate multimodal composing skills, to practice collaboration, and so on? The answer to this requires us to look beyond our current models into one that re-conceptualizes writing as making, that is, a "maker" approach to TPC pedagogy.

1.6 A research opportunity: The Maker Movement

Across many fields, particularly education, engineering, and business, the Maker Movement and its philosophy have been adopted for creating innovative, open, and collaborative communities of learners and makers (Hagel, Brown, & Kulasooriya, 2013; American Society of Engineering Education, 2016). In these communities—fondly known as makerspaces—students cultivate a strong sense of agency in solving problems they identified as important through a design-thinking process. This process requires students to combine creative and analytical approaches to define problems and invent desirable solutions by collaborating with others. Although not limited only to schools and university campuses, most makerspaces today are built within an education setting (Carlson, 2015). The idea of a Maker Education is to create such spaces where students collaborate across disciplines and tackle complex problems.

While it may seem far-fetched at first, there are a number of recognized connections between making and writing. For one, making, much like writing, is process-oriented; it involves the drafting and composing of an artifact, trial and error, revision, and reflection (Gierdowski & Reis, 2015). One might also recognize the similarities between making and the growing conversation about multimodality that is taking place in the areas of rhetoric and composition, computers and writing, and digital rhetoric. In writing studies, we have been challenged to reconsider what we see as "texts," as James Porter (2002) points out, "We are already in the age of new media, where visual and video forms of expression supersede alphabetic text" (p. 389). The material outcome of a "making" could very well communicate a message the same way as conventional alphabetic texts, if not more effectively. What's more, the project-focused, process-oriented maker approach that favors co-creation is comparable to the participatory, collaborative knowledge-making practices that are highly regarded in rhetoric and composition studies (i.e., Ede & Lunsford, 1991). Finally, emphasizing the importance of translating knowledge into practical application, Miles Kimball (2017) stresses the need to leverage the technical communication classroom for change-making:

> Compositionists are rethinking general college writing instruction, for example by having students write "multimodal" compositions. … This change reflects a growing awareness of the importance of technology in human communication. Multimodality, however, does not always emphasize instrumentality; many multimodal compositions are simply expressive writing in multiple media. We owe all students an opportunity to learn how to communicate in a technological world—not just by writing a multimodal essay instead of a lexical essay, but by learning to use technologies of communication to bring about practical change. Technical communication is ideally situated to help do just that. (p. 350)

Given these observations, I see an opportunity to identify the viability of a maker pedagogical approach for TPC.

This dissertation investigates how students create multimodal solutions to address complex problems via technology-enhanced maker practices informed by design thinking. As a result, it will identify useful pedagogical intersections between the Maker Movement proper and TPC. Further, I am interested in developing a model for application of maker pedagogy to teaching TPC that emphasizes design thinking and multimodal literacy. These concepts matter to TPC for at least two apparent reasons. First, as Kelli Cargile Cook (2002) argues, multimodal rhetorical skills encourage "students to understand and be able to analyze, evaluate, and employ various invention and writing strategies based upon their knowledge of audience, purpose, writing situation, research methods, genre, style, and delivery techniques and media" (p. 10). These skills are crucial for students to be successful, agile technical and professional communicators today. Second, as Jody Shipka (2005, 2011, 2013) demonstrates, design thinking and multimodal literacy can also help bridge the gap between academia and workplace through the varied communicative and composing practices students engage in the classroom that may also be performed in the workplace, such as websites and multimedia presentations.

The contribution I hope to make toward our field via this dissertation is to expand our understanding of multimodal literacy—how we might approach and foster it—and how students can learn to compose and create "texts" that solve their problems at hand. Moreover, as the TPC workforce is predominated by a collaborative and innovative culture, another significance of this research will be the creation of a pedagogical framework with heuristics that prepare students for the kind of work environment where a maker mindset is expected.

1.7 Relevance to Rhetoric + Scientific & Technical Communication

I envision this project to be a contribution to the large discipline of rhetoric and writing studies but also specifically to scientific and TPC. In Figure 1, I illustrate the interconnectedness of the various key tenets explored and explicated through this dissertation. For rhetoric, I add to our existing knowledge on invention and the composer's rhetorical awareness through the integration of rhetoric and design thinking. Design thinking offers fresh perspectives to understanding the rhetorical situation of the problem at hand. In *Rhetoric and the Arts of Design*, David Kaufer and Brian Butler (1996) claim that "rhetoric and design are structurally similar" (p. 37). This dissertation project continues the examination of rhetorical invention as a designerly activity proposed by Kaufer and Butler. Driven by design thinking, making invites a certain kind of thinking and responding that is important to technical communicators today. The entrepreneurial nature of the current maker culture provides a vital foundation for students to work in a non-linear process, trying multiple strategies to arrive at a plausible solution. It lets students practice employing multiple modalities to construct their solutions. This, for scientific, professional, and technical communication, creates new approaches for teaching and learning that respond to the current industry needs. Beyond intersecting with rhetoric and TPC, I argue that making and design thinking foster new thinking and practices that challenge our constructions of learning spaces, draw attention to collaborative problem solving, and support student agency. I present these implications in this dissertation.

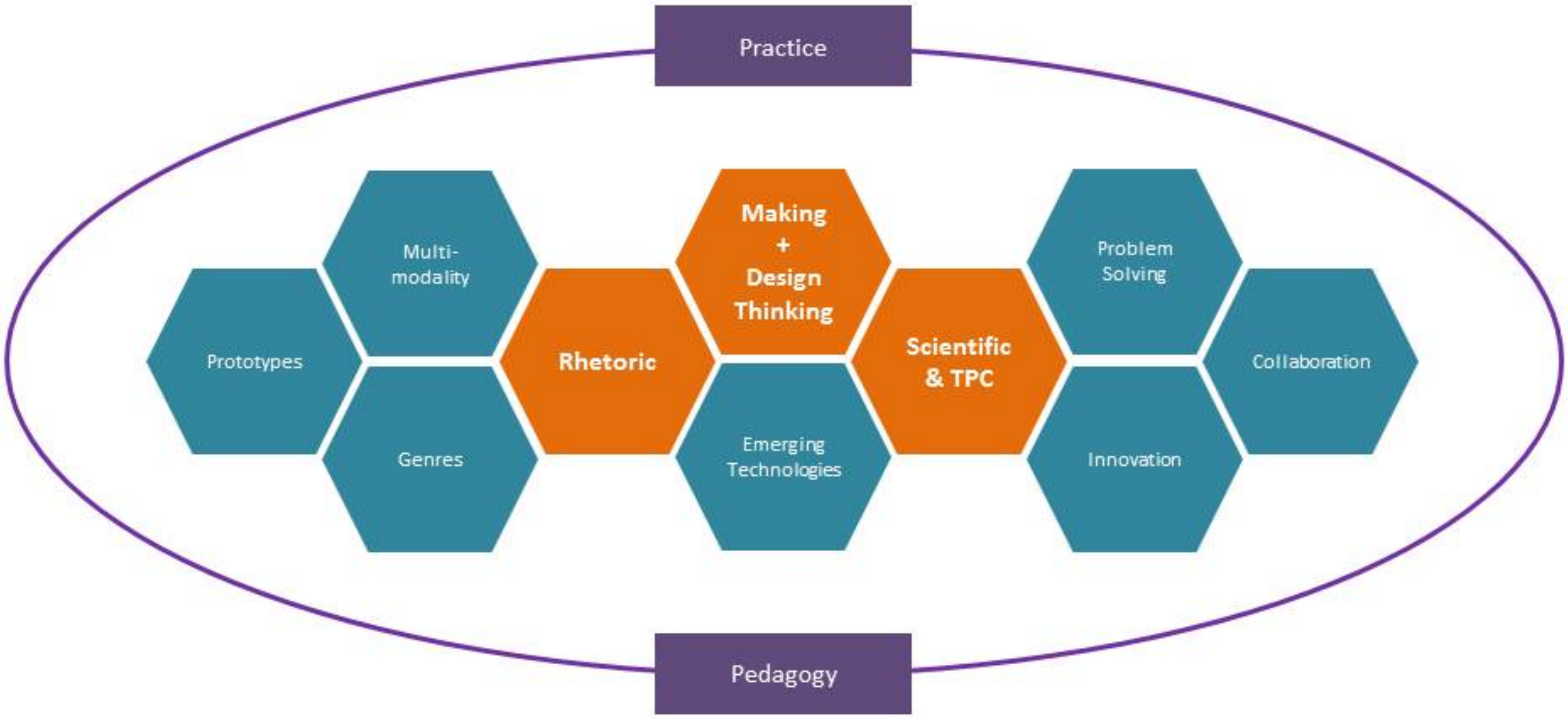

Figure 1. The interconnections of key tenets in this project: Making & design thinking, rhetoric, scientific & TPC, problem solving, innovation, collaboration, emerging technologies, multimodality, genres, and prototypes. Graphic created by author.

1.8 Overview of the dissertation

In the next chapter, **Chapter 2**, I provide a detailed account of the Maker Movement and its current impact on instruction. With an eye toward its benefits for addressing the "wicked problems" raised in this chapter, I outline the pedagogical relevance of making for TPC.

Chapter 3 offers a focused literature review of four major tenets that make up the theoretical foundation of this dissertation, namely 1) constructionism and constructivism, 2) social and collaborative learning, 3) multimodality, and 4) design thinking in writing. These literature sources inform the research questions for this dissertation project, which I present in **Chapter 4**. There I also present the design of my study and the methodology for data collection and analysis.

In **Chapter 5**, I describe and review the findings from a multi-site ethnographic case study. I provide the details from a comparison of three academic makerspaces—at Georgia Tech, Case Western Reserve University, and the University of Minnesota. Based on my observations of these makerspaces, I devise a "maker" approach to TPC pedagogy for application in a pedagogical case study.

In **Chapter 6**, I report findings from the case study of a TPC course that employed maker practices. I describe the course setup and assignments and showcase some student projects. I also include student responses and reflections from this course.

Combining the results from my makerspace visits and pedagogical case study, I discuss in **Chapter 7** the implications of a maker pedagogy for TPC, including the cultivation of a new mindset, disruption to conventional ideologies, and the exploration of a material dimension to writing. I also discuss ways in which making can be assessed in the context of TPC instruction.

I conclude this dissertation with **Chapter 8** by summarizing the key takeaways from this research, identifying its limitations, and providing a set of directions for future studies.

CHAPTER 2

Making, Maker Movement, and Makerspaces

This chapter provides an overview to the notion of making and makers as they are presented in the context of this dissertation, and offers critical background information on maker culture and makerspaces in academic and higher education settings. I begin by defining some key terms surrounding the Maker Movement by describing their main characteristics.

2.1 Key terms and critical information

The **Maker Movement** is an informal, umbrella term referring to an emerging subculture that arises from grassroots networks through a shared interest in collective or collaborative tinkering on creative and technical projects. Broadly, the Maker Movement is propelled by a culture of making and hacking (in a positive sense) that favors democratic and meritocratic conventions to organized production. It encourages bottom-up organizational practices that seek to foster open and social learning. The maker culture is also typically associated with design thinking, a set of methodology that guides human-centered solutions and iterative design processes. Dale Dougherty, founder of *Make:* magazine—one of the core media outlets supporting the Maker Movement—and creator of Maker Faire, describes the Maker Movement as follows,

> When I talk about the maker movement, I make an effort to stay away from the word “inventor”—most people just don’t identify themselves that way. “Maker,” on the other hand, describes each one of us, no matter how we live our lives or what our goals might be. (Dougherty, 2012, p. 11)

> The maker movement has come about in part because of people’s need to engage passionately with objects in ways that make them more than just consumers. But other influences are in play as well, many of which closely align the maker

> movement with new technologies and digital tools. Makers at their core are enthusiasts, such as those engaged in the early days of the computer industry in Silicon Valley. We've lost sight of that aspect of the computer industry because the devices they create have become so widespread and people no longer need to be enthusiasts to use them. But those makers in the early days of the computer industry were essentially playing with technology. They didn't know what they wanted computers to do and they didn't have particular goals in mind. They learned by making things and taking them apart and putting them back together again, and by trying many different things. (Dougherty, 2012, p. 12)

On a more tangible level, the Maker Movement can be recognized by the rapid-prototyping tools and methods it employs. *Make:* magazine defines the Maker Movement as a "combination of ingenious makers and innovative technologies such as the Arduino microcontroller and personal 3D printing [that] are driving innovation in manufacturing, engineering, industrial design, hardware technology and education" (n.d.). Besides the technologies that support making, the Maker Movement can also be characterized by collective organizations that maintain workshops for projects involving welding, metal or woodwork, and electronic circuit design and programming. These physical spaces are fondly known as digital fabrication labs (or fablabs), techshops, hackerspaces, or more generally makerspaces. Each of these space classifications has their own unique emphasis.

Fablabs are popularized by the Stanford University Graduate School of Education's FabLearn[3] program and the MIT's Fab Foundation[4]. The emphasis of fablabs is on learning through research and invention. **Techshops**, popularized by the entreprise chain TechShop, are typically membership-based community studios equipped with industrial tools for fabrication. While fablabs and techshops are more structured by their US-based organizational philosophies, hackerspaces trace their origin to the European hacker culture. **Hackerspace** members usually tell a story of when their "founding leaders," a group of North American computer programmers visited Germany's Chaos

[3] See https://tltl.stanford.edu/project/fablearn-labs
[4] See http://www.fabfoundation.org/

Computer Club in 1997 (Maxigas, 2012) and grew excited about creating similar spaces in the US. Semiotic disputes over the terms hackers and hacking have not stopped hackerspace users to stand firm on their theoretical perspective. Today, hacking typically refers to creative ways to work around everyday life issues. Terms like "lifehacks," "schoolhacks," and "gradhacks" (specific to graduate students) are grown out of this tradition.

Figure 2. A makerspace at Vassar College, New York.

A **makerspace** is the most common reference used to identify an open workspace dedicated to maker culture practices. Some say makerspace is a term coined by the *Make:* magazine when it was launched in 2005. It became further popularized the magazine's founder, Dale Dougherty, registered makerspace.com in 2011 and started using the term to refer to open-access spaces for designing and creating (Cavalcanti, 2013). Within academic settings, schools, libraries, and universities tend to call their design and production spaces makerspaces given the neutrality in the name. Educause identifies a makerspace as "a physical location where people gather to share resources and knowledge, work on projects, network, and build" (Educause, 2013, n.p.). The Vassar College makerspace (Figure 2) defines makerspace as spaces that

> combine manufacturing equipment, community, and education for the purposes of enabling community members to design, prototype and create manufactured works that wouldn't be possible to create with the resources available to individuals working alone. These spaces can take the form of loosely-organized individuals sharing space and tools, for-profit companies, non-profit corporations, organizations affiliated with or hosted within schools, universities or libraries, and more. ("What is a makerspace," 2015, n.p.)

With increasing growth of makerspaces within universities and other academic institutions, the term "academic makerspaces" is increasingly used to specify a distinguishable field dedicated to studying makerspaces in higher education contexts.

The influence of the Maker Movement in higher education is evident in the growing development of makerspaces in universities across the United States. To share resources and address makerspace-related problems collaboratively, leading institutions including Yale University, Stanford University, Carnegie Mellon University, and the MIT[5] have joined forces to form the **Higher Education Makerspaces Initiative** (HEMI[6]). Since 2016, HEMI has been responsible for convening the annual International Symposium on Academic Makerspaces (ISAM[7]), a conference that brings together makerspace managers and researchers from around the world to identify and address emerging issues around academic makerspaces. These issues span from technical design (i.e., how to track user traffic in a makerspace) to pedagogical implications (i.e., what kind of curriculum might be created around making). During the 2017 ISAM conference, hosted at Case Western Reserve University, more than half of the speakers focused on the values of academic makerspaces for cultivating STEM literacy as well as their impact on humanities disciplines in higher education. Across the board, academic technologists,

[5] Other founding institutional members include University of California Berkeley, Case Western Reserve University, Georgia Institute of Technology, and Olin College.
[6] See https://hemi-makers.org/
[7] See https://isam2017.hemi-makers.org/

librarians, and literacy educators alike seem invested in the idea of making as a way to engage students in active learning, hence contributing to the growth of Maker Movement in higher education.

Making is also becoming popular within our own field of rhetoric and writing. Local and national conferences such as Computers and Writing, Conference on College Composition and Communication (CCCC), and Feminist Rhetorics (FemRhet) have implemented various iterations of maker sessions at their respective conventions. It is not uncommon to attend any of these conferences now and be graced by the presence of a MakerBot 3D printer (usually printing the conference logo or the host university emblem) and microcontrollers or microprocessors like Arduino circuit boards for quick prototyping of creative ideas. Since 2013, making has earned a place in the Computers & Writing (C&W) conference program. The 2013 C&W conference included a fablab tour and workshop. The 2014 C&W conference featured a special workshop discussing making as "hacktivism" (hacking as civic activism). In 2015, a workshop was dedicated to 3D modeling and 3D printing. In 2016, more than a dozen of presentations focused on makerspaces and making as composition. And more recently, the 2017 C&W conference hosted a circuit-crafting session focusing on creating paper-based circuits (see Figures 3 & 4). In 2018, making was a part of the C&W conference theme with "code" and "play" being the juxtaposed as the rhetorical frames of techne and phronesis. At the regional level, the 2017 Great Plains Alliance for Computers and Writing had dedicated a full-day pre-conference workshop engaging its participants with various types of makerspaces at the host university, University of Minnesota. Participants of the workshop were exposed to making across the disciplines—including arts and fashion design, mechanical engineering, education, and liberal arts technologies. Certainly, maker culture goes beyond the computers and writing community. In 2017, the biennial Rhetoric Society of America Institute hosted a digital rhetoric seminar focusing on physical computing and digital fabrication. Also in 2017, the annual FemRhet conference designated special "maker sessions" as action-driven workshops in accordance to the conference theme.

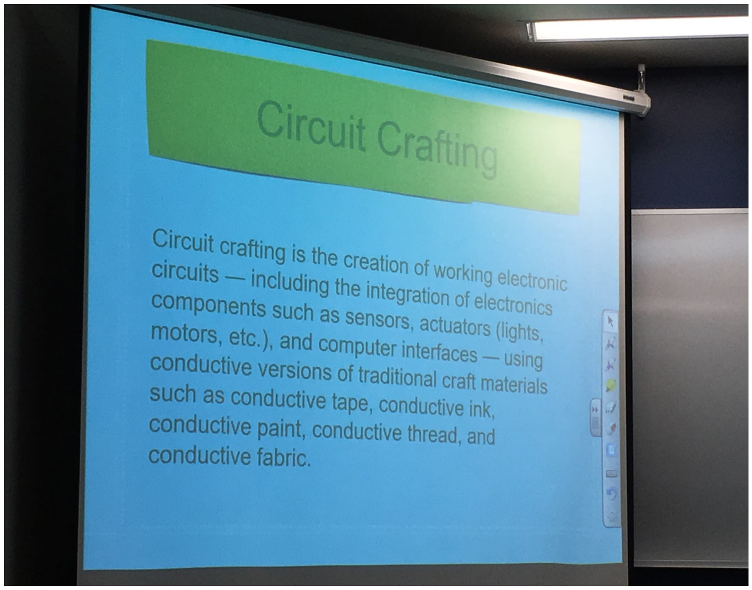

Figure 3. Circuit crafting session at the 2017 Computers and Writing conference. Photograph shows a slide presentation with the presenter's definition of "circuit crafting."

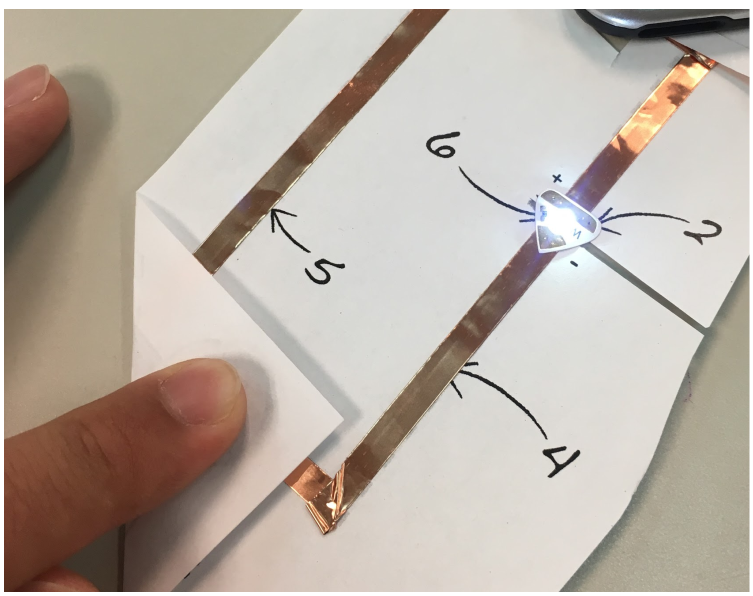

Figure 4. Photograph shows the author's paper circuit made at the 2017 Computers and Writing conference.

The growing interests at the institutional and disciplinary levels create an imminent exigence for writing studies scholars. Such exigence is concerned with the goal of making and its pedagogical relevance in TPC pedagogy. To address these concerns, we can start by understanding the historical development of the maker culture and how the Maker Movement came to be in educational settings. The following pages unveil the elements that make up the maker culture and its subsequent influence on the educational Maker Movement.

2.2 A brief historical account of the development of the Maker Movement

Certainly, the Maker Movement did not just begin a few years ago; its roots are connected to industrialism and mass manufacture. According to Elizabeth Cumming and Wendy Kaplan (1991), designers and labor theorists in Victorian England have created an early reaction to industrialization. They have sought to value individualism and creativity amid a time of profits and mass-market capitalism. According to Breaux (2017), art critic John Ruskin was another important figure in the movement that publicly called for organic design and production and the end of the machine-driven model of Victorian production. By the 1890s, as Cumming and Kaplan (1991) document, there have been several large craft shows that occurred throughout England. The turn of the century witnessed the golden age of the Arts and Crafts Movement.

In their book, *Adhocism*, Charles Jencks and Nathan Silver (2013) report that the Arts and Crafts Movement suffered an apparent decline following the First World War. This has led to the rise of the ad hoc practice of do-it-yourself, or DIY, a new method of assembling using readily available components and tools. Jencks and Silver (2013) suggests that doing-it-yourself is “the rebirth of a democratic mode and style, where everyone can create his personal environment out of impersonal subsystems, whether they are new or old, modern or antique. By realizing his immediate needs, by combining ad hoc parts, the individuals creates, sustains and transcends himself” (p. 15). For Jencks and Silver (2013), this form of creative and self-powered assemblage is a way of resisting the “omnipresent delays caused by specialization and bureaucracy” (p. 19). It resembles a postmodern viewing of a pluralist world containing multiple ideologies—fragmented, but can be reassembled as necessary, yet not always cohesive. Jencks and Silver (2013) also point to the counterculture movement coinciding with industrial and cultural forces as the roots of DIY culture. Particularly, the emphasis on reusing or repurposing industrial excess serves a great example of adhocism at work (p. 65–67).

Evgeny Morozov (2014) notes in *The New Yorker* that although the Arts and Crafts Movement was deemed dead post World War I, the sentiment behind it lingered. "It resurfaced in the counterculture of the nineteen-sixties, with its celebration of simplicity, its back-to-the-land sloganeering, and, especially, its endorsement of savvy consumerism as a form of political activism," Morozov (2014, n.p.) writes. Evidently, it wasn't just for political purposes but business marketing as well. Morozov highlights the corporate gimmicks organizations like Apple, Stanford's Artificial Intelligence Laboratory, and even MIT used to convince consumers that they were rebels. The hippie term "hackers" became a slang to those who wished to distinguish themselves from the rigid, unimaginative technocrats. Soon, the talk of "de-institutionalization of the society" with rising personal computing technologies became a slogan for self-proclaimed anticulture tech elites, many of whom were also subscribers of Stewart Brand's *Whole Earth Catalog*[8] (see Figure 5 and Figure 6), circa 1968–1972 (Morozov, 2014). Brand's counter-mainstream rhetoric is deeply ingrained into the culture of making today.

[8] Per crowdsourced knowledge—aka Wikipedia—"the *World Earth Catalog* was an American counterculture magazine and product catalog published by Stewart Brand several times a year between 1969 and 1972, and occasionally thereafter, until 1998." One could argue the current popular magazine, *Make:*—known for its affiliation with maker faires and other large-scale maker initiatives—is a successor of the *Whole Earth Catalog* given their similarity in content.

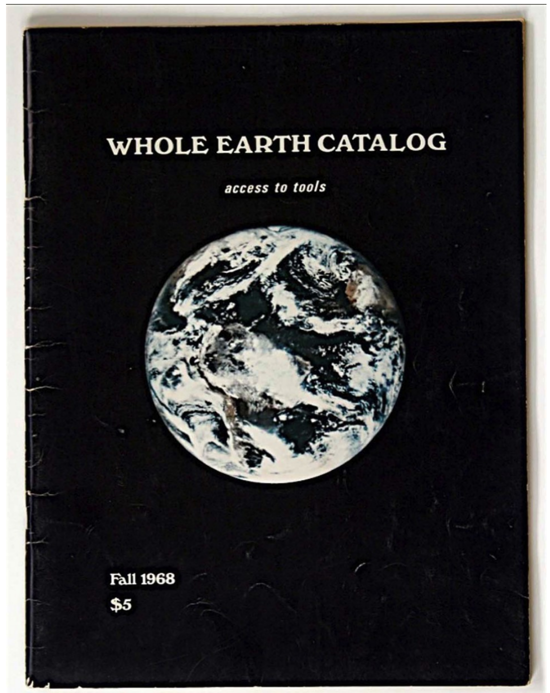

Figure 5. Cover of the *Whole Earth Catalog*, first issue (Fall 1968).

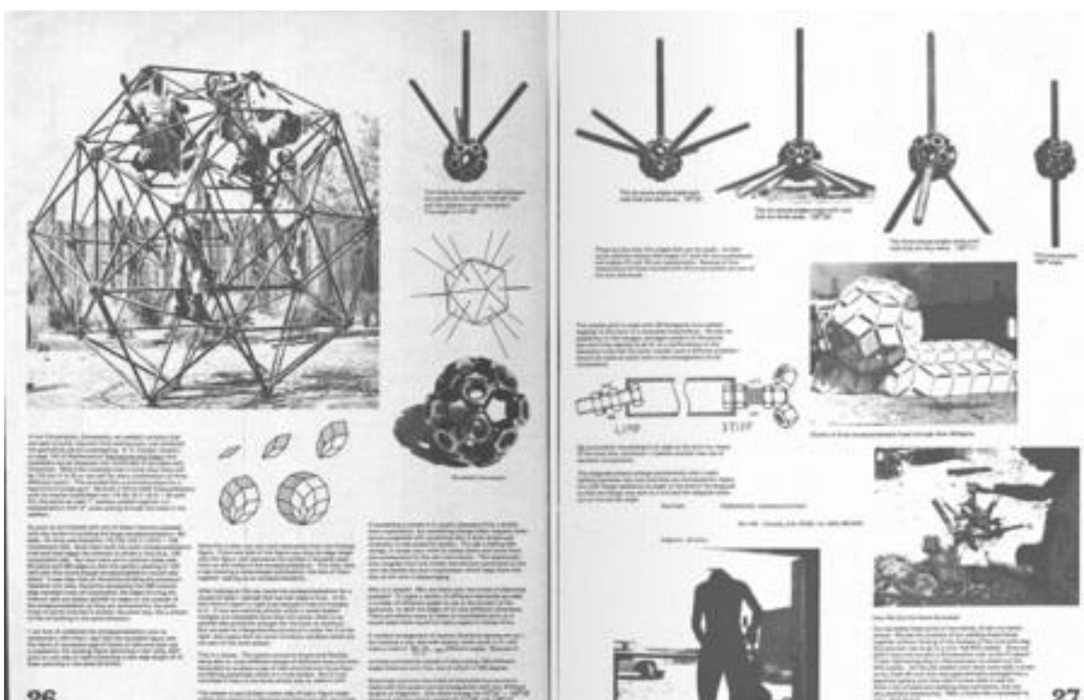

Figure 6. An example spread from a *Whole Earth Catalog* issue that preached a hacker/designer approach to everyday life.

These historic movements and influences are important to establish the lineage of making. While maker practices did not emerge overnight, many developments and continued ideologies of crafting, self-assembling, and hacking demonstrate the persistence of these ideas. The Maker Movement is born of a tradition of artisanship, self-sufficiency, and the subsequent anti-culture techno-enthusiasm. What differs the Maker Movement from its preceding history, however, is the infrastructure that allows makers to become truly makers—the well-equipped makerspaces and community of practice that celebrate DIY mindset and entrepreneurship. In the next section, I discuss the impact of these infrastructural elements—and culture—that fuel the Maker Movement.

2.3 A new culture of making and makers community

While there are no specific events that led to the booming of the maker culture, the notion of making as an intentional, inventive, and innovative practice is popularized by narratives around emerging technological solutions and rapid prototyping as they are increasingly supported by affordable desktop manufacturing technologies like 3D printers. A common interpretation of the maker culture is that they are a computer-based, technology-enhanced extension of the do-it-yourself (DIY) culture. In his book, *The Maker Movement Manifesto*, Mark Hatch (2013) describes how our existing culture perpetuates the maker culture:

> Wars have been fought when the common people thought they were going to lose access to ownership of their own productive tools. So the first thing we must do is make. The do-it-yourself (DIY) home improvement industry in the United States is worth over $700 billion. The hobbyist segment is worth over $25 billion. The most valuable segment of the $700 billion DIY is the perpetual remodeler, specifically those who have enough money to let business professionals do the work for them, but don't. You might know or even be one of these people. In your heart of hearts, you know you don't really need to redo the bathroom, or certainly

> not the way you plan to do it yourself. But you do it anyway. This is because there is more satisfaction in completing the remodel yourself. (pp. 12-13)

Besides the "satisfaction" factor, schools and homes have continued to encourage making as a creative and desirable endeavor. We are slowly moving from praising originality to applauding different means of expression that involve modification, remix, and redistribution. In schools, students across all education levels are taught to discuss how they feel about the texts they encounter. They are usually asked to respond by composing syntheses of texts with their own reflections. At home, children are taught to build and fix. We give young children toys like LEGOs and PlayDough that encourage imaginative building. When they are older, we find it necessary to teach them about household maintenance, such as changing a lightbulb, fixing a leak, and building a shelf. In these activities we often add to existing structures or modify their design based on the purposes or constrains we are working with. Generally speaking, we subscribe to a culture that believes in taking matters into our own hands—solving problems on our own. Such culture, plus an increasingly affordable access to additive manufacturing technologies and fabrication tools, boosts the maker culture. To this end, Mike Rose (2004), a familiar figure in our field, draws a connection between the maker culture and education:

> We seem to have discovered the pleasures of working with our hands—or at least of using products that are handmade or manufactured on a small scale, artisanal, locally produced. […] In education, there is growing interest in making and "tinkering" to foster, in one organization's words, "imagination, play, creativity, and learning." As opposed to some anti-technology expressions of this hands-on spirit in the modern West, our era's movement embraces technology—computers and digital media are as much a part of the Makers Movement as woodworking and quilting. The same holds for education, which wants to draw on young people's involvement in computer technology and social media. (2004, p. 56)

We are a culture not only already submerged in the maker culture but also in creating makers. In the context of the Maker Movement, a maker is a blanket name for creators, designers, developers, programmers, etc.—all those who go beyond just thinking about ideas into tinkering with different ways to materialize their ideas. Several characterizations[9] of makers set them apart from any creator. Makers embrace an entrepreneurial spirit that motivates them to pursue radical solutions and are biased toward actions. While they do not necessarily have to exert high energy at all times, makers are often passionate about their ideas and that passion is reflected in their designed artifacts. Since collective work is a signature characteristic of the Maker Movement, makers often engage in sharing (ideas, tools, spaces) and collaborating with others.

When makers participate in shared events and collective invention, they form a network called a maker community. A common maker community is Maker Share[10], an online project space where makers share ideas, methods, tools, and directions for perfecting one another's projects. Maker communities also manifest in the form of in-person project showcase, called a Maker Faire. Maker Faires are locally organized events (similar to TEDx talks) where cities or counties work with the chief sponsor *Make:* magazine and local makerspaces to put together a series of showcases and competitions. According to the official Maker Faire website[11] ("Maker Faire: A bit of history," n.d.), these events are "an all-ages gathering of tech enthusiasts, crafters, educators, tinkerers, hobbyists, engineers, science clubs, authors, artists, students, and commercial exhibitors. All of these 'makers' come to Maker Faire to show what they have made and to share what they have learned" (n.p.). In the Twin Cities, the annual Minneapolis-St. Paul Mini Maker Faire[12] has been held every summer at the Minnesota State Fairgrounds since

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[9] There has been critique over the use of the term "maker" as a masculine term privileging white, male, able-bodied creators versus their counterparts. Art professor Diane Willow at the University of Minnesota shares a story in her experience wherein a female colleague who invented the technology for the LilyPad e-textile circuit board was noted as a "crafter" rather than "maker" due to her female identity. For the purpose of clarity and consistency, I use "maker" as an androgynous term to represent all creators who embody the spirit of the Maker Movement.
[10] See https://makershare.com/
[11] See https://makerfaire.com/makerfairehistory/
[12] See https://msp.makerfaire.com/

2014. According its website, makers/exhibitors can have a booth, give a presentation, lead a workshop or be a performer at the Maker Faire. In 2017, it featured an Education Day[13] for 7th graders and teachers to "try their hands at coding, flying a drone, screenprinting, soldering and building their own projects." The Education Day was featured again in conjunction with the 2018 Maker Faire plus 1,000 free spots for students in schools that do not meet the $5-per-student threshold.

2.4 Maker culture as a new work culture

Initially, the idea of a makerspace emerged as an informal learning space in nonacademic communities. Will Holman (2015), a general manager of a Baltimore-based makerspace, has found some early makerspaces formed by the public sector:

> In London, during the deep recession of the early 80s, voters elected a leftist city council to protest the austerity policies of the Thatcher government. Labour politicians quickly set up the Greater London Enterprise Board, which in turn established five Technology Networks with a budget of £4 million. These facilities, direct antecedents to modern makerspaces, were shared machine shops that aimed to democratize the means of production and access to education for unemployed manufacturing workers. (Holman, 2015, n.p.)

Citing technology scholar Adrian Smith (2014), Holman (2015) reported that participants developed various prototypes and initiatives that created the idea of an "open access product bank" that distributes profits from inventions directly back to the members of the makerspace. Fast forward 20 some years, the maker culture has grown out of the mechanical industry into the tech industry. Social media giant Facebook, for instance, integrates intentional makerspaces (called hackerspaces) to sparkle innovative ideas. First took place in 2007, the annual Facebook "hackathon" is designed for software engineers to move out of their regular silos or workgroups to collaborate with those they do not typically work with for the purpose of radical innovation. On a company page, former

[13] See https://msp.makerfaire.com/education-day/

Facebook engineering director Pedram Keyani (2012) praises the company's hackathon initiative,

> Hackathons are a chance for engineers, and anyone else in the company, to transform the spark of an idea into a working prototype and get other people excited about its potential. We're a culture of builders, and hackathons are our time to take any idea—big or small, sane or crazy—and build it into something real for people to react to. Instead of worrying if their idea will scale for more than 900 million people, people are able to focus on getting their basic project up and running so the broader team can quickly iterate to make it better. (Keyani, 2012, n.p.)

Other tech industry leaders, such as Google and Microsoft, have also embraced the Maker Movement. Google has reportedly rewarded employees through a "20% time program" that encourages them to work on innovative ideas outside of their job purview (Pink, 2011) and Google Workshops is known to be the collaborative space for these activities. In fact, 3M Company was credited for starting a "15% project" time reward in the 50s. At Microsoft, The Garage is a dedicated space for experimental projects. According to its official page,

> The Garage is a resource to Microsoft employees that supports and encourages problem solving in new and innovative ways, ultimately empowering people to achieve more. (The Garage, n.d.)

As with any given culture, the ethos of a tradition (old or new) should be examined from social, political, and economic significance. While making is normalized in industry, we must also acknowledge issues of social class relevant to the Maker Movement as they are becoming more central to the shaping of policies involving work and training. In the socioeconomic context, maker culture is critiqued by some as a political philosophy and social movement, as Rose (2014) notes,

> By and large, the Makers Movement is a middle-class movement. Working-class folk have not had the luxury of discovering making and tinkering; they've been

> doing it all their lives to survive — and creating exchange networks to facilitate it. Somebody across the street or down the road is a mechanic, or is wise about home remedies, or does tile work, and you can swap your own skills and services for that expertise.

Nevertheless, corporate makerspaces serve as a major force that pushed the hacker-maker ethos from geek-dom into mainstream. The MIT Center for Bits and Atoms were among the first non-corporate units that installed a digital fabrication facility gathering tools and materials appropriate for fast prototyping. In 2005, the world's first official Fab Lab opened at MIT—a "technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship" (Fab Central, n.d.)—which has since grown from one location in South Boston to a network of 59 labs throughout the United States and 579 internationally (Holman, 2015). Given their hands-on character, coupled with tools and raw materials that support radical invention, makerspaces have soon caught hold in education as they provide an ideal space for learning by doing.

2.5 The Maker Movement in education

As part of the larger DIY movement, the Maker Movement emphasizes learning-through-doing and informal, networked, peer-led, shared learning experiences. In the K-12 context, digital fabrication labs and maker studios are popular among those who are advocates of a "STEAM" curriculum (science, technology, engineering, arts, and mathematics) that is based around interdisciplinary and project-based learning that integrates art and design into the traditional STEM fields. These studios mirror a workshop setup and are equipped with rapid prototyping tools such as 3D modeling software and printers, threads and fabrics, circuit boards, and other material supplies to allow students to focus on experimenting and refining their ideas, rather than getting it right at once. Many makerspaces in schools are open for drop-in or unscheduled activities, although more schools are beginning to organized scheduled learning in these spaces. The White House (Nation of Makers, n.d.) has openly acknowledged and promoted the values of the Maker Movement in education when it hosted its first White House Maker Faire[14] in 2014, making Maker Education a household name among teachers. Many school districts are now funded to launch their own fabrication program, receiving major support from governmental branches such as the US Office of Educational Technology (n.d.) and the National Science Foundation (2015), as well as corporate donors.

Colleges and universities are also quickly recognizing the value of the makerspace as a learning opportunity. However, unlike their K-12 counterparts, most higher-ed makerspaces are built in libraries and learning commons their respective college campuses, and to name a few:

- ThinkLab at the University of Mary Washington,
- Headquarters at Rutgers University,
- FabLab at Stanford University.
- Launch Lab at Youngstown State University,
- Invention Studio at Georgia Tech,
- Think[box] at Case Western Reserve University, and
- WHALE Lab (Wheaton Autonomous Learning Lab) at Wheaton College.

In support of the Obama Administration's effort in promoting Maker Education, more than 200 universities and colleges, including the University of Minnesota, signed a joint letter to the president in June 2014 articulating the significance of the Maker Movement in American education (Executive Office of the President, 2014). In terms of objectives, universities tend to focus on cross-disciplinary collaboration and documenting innovation process so products from the makerspaces can remain open access and open source. In "A Review of University Maker Spaces," Thomas Barrett and colleagues (2015) compared 40 university based makerspaces and find an overwhelmingly similar narrative among them that these spaces "provide a central location for many campuses trying to encourage multidisciplinary activity" (p. 14). More and more, university/campus

[14] Since the Obama Administration's retirement post-2016 presidential election, the White House has not provided official support to the Maker Movement nor hosted any Maker Faire. The Nation of Maker project can be found in the Obama Administration's web archives.

makerspaces are positioning themselves to be an interdisciplinary hub, and this provides a unique opportunity for writing studies to participate in the movement and establish fruitful connections with disciplines that would enrich our field and our students.

2.6 Making and writing: The pedagogical relevance

In "Making Across the Curriculum: DIY Culture, Makerspaces, and New Modes of Composition," Jessica Elam-Handloff (2016) testifies through her experience in running a library makerspace that, "Makerspace contribute to the larger conversation regarding questions of the place and legitimacy of digital scholarship, demonstrating the desire of cross-disciplinary students, faculty, and staff to spread making across the curriculum, even in expected places" (n.p.). Making is thus beyond just the physical makerspaces and made objects themselves, but rather the experience of making collaboratively, and the learning that happens amidst that making. Similarly, Maggie Melo (2016) contends that such embodied learning in a makerspace makes for better student writing.

In "Composing the Carpenter's Workshop," James Brown and Nathaniel Rivers (2013) envision an object-oriented future for writing studies, one where students compose objects like puzzles and glass sculptures with ads and packaging for their objects. This future that Brown and Rivers imagine is partially an extension of Shipka's (2011) multimodal composition theory and partially an enactment of Ian Bogost's (2012) call to include *all matter* and not just "written matter" in humanities scholarship. In 2012, the Council of Writing Program Administrators (CWPA) began revising the Outcomes Statement (which originally named five values traditionally associated with academic writing: rhetorical knowledge; critical thinking, reading, and writing; flexible writing processes; and knowledge of convention) to better account for the increasing presence of multimodal composing in writing classes—evidence that new materialism is gaining prominence in our field. As David Sheridan (2010) writes, "three-dimensional objects do indeed function rhetorically and may even possess their own distinctive rhetorical power. In fact, three-dimensional objects appear to play a unique role in fashioning culture itself"

(p. 255). Given these affordances, the Maker Movement, focusing on inventing and interacting with objects, might point us to a dimension of composition that is less explored in traditional writing studies, one that better tackles the wicked problem of teaching writing than print-driven methods.

The National Writing Project (2013) has also recognized this natural connection between making and writing, and has actively engaged a constructionist approach to engaging making. In 2013, the National Writing Project teamed up with the MacArthur Foundation and Mozilla to sponsor a Summer of Making and Connecting[15], and in 2014 to sponsor a Summer to Make, Play, & Connect. In July 2013, the National Writing Project teamed up with Connected Educators to host a series of webinars for Connected Learning TV called "Writers at Work: Making and Connected Learning[16]." In the same year, the National Writing Project conference had Jie Qi of The MIT Media Lab's High-Low Tech Research Group and members of the San Francisco-based NexMap offer a "hack your notebook[17]" seminar based on Qi's work with paper circuits (Buran, 2013; Rheingold, 2014); and the National Writing Project and the Educator Innovator Network sponsored a "Hack Your Notebook Day" in July 2014 (Zamora, 2014). These instances serve as precedents to the potential gains and values of a maker culture in writing studies. The future of writing pedagogy from a maker education perspective remains promising as more ad-hoc groups and research teams are making space for makerspaces in higher learning settings.

2.7 Chapter summary

This chapter has included an overview of making in the context of the Maker Movement, its origin, and associated exercises that promote a culture of DIY problem-solving using technology-enhanced fabrication tools like 3D printers and microprocessing circuit boards. The chapter has attempted to describe what making

[15] See http://www.makesummer.org/
[16] See https://thecurrent.educatorinnovator.org/resource/writers-at-work-making-and-connected-learning
[17] See http://www.nexmap.org/hack-your-notebook-day-kits/

means and looks like in academic and pedagogical settings. Starting with a brief historical review of the Maker Movement, I have focused on how our self-sufficient and entrepreneurial cultures have perpetuated a maker culture, which is further supported by a global network called Maker Faire. The parallels between making and learning in work and educational settings continue to bolster the growth of the Maker Movement. This chapter closes with a discussion on the pedagogical relevance of making in writing studies. In the next chapter, I review the theoretical frameworks that inform a maker approach to writing pedagogy, including constructionism learning theory, active learning through collaboration, design thinking principles, and multimodality in writing and making.

CHAPTER 3
Learning in the Making: Theoretical Frameworks

This chapter provides an overview to the theoretical frameworks that underscore the nature and design of this dissertation project. I begin by reviewing two main learning theories, namely constructionism and constructivism, as they pertain to the Maker Movement, followed by social learning approaches as they have been identified in writing/TPC pedagogy. While these learning theories have a long history in our field's literature writ large, they need to be revived in our technological age to provide insights to the infusion of making in teaching and learning. Then, I synthesize major conversations around multimodality to present the gap between students' consumption and production of multimodal artifacts. Finally, I make a connection between design thinking and writing studies as a way of addressing this gap. This chapter builds on the exigence presented in the previous chapters that TPC pedagogy needs to update its approaches to respond to changing compositional practices.

3.1 Constructionism, constructivism, and making

Making as an approach to TPC pedagogy has the potential to become a high-impact instructional practice given the values it offers to activate hands-on learning. To date, most literature cites constructionism as an underlying principle of maker education (Donaldson, 2014; Vaughn, 2017). However, within writing studies, the most widely known and promising pedagogical approach is constructivism, which is grounded in the works of Jean Piaget, Lev Vygotsky, and Jerome Bruner. This divergence presents a kairotic exigence to examine where these theories imbricate and how they differ from each other to provide new depth to TPC pedagogy. In this section, I synthesize the learning theories of constructivism and constructionism, and argue that both contribute to the construction of a maker pedagogy.

3.1.1 Constructivism

As its name suggests, constructivism is concerned with the active effort involved in knowledge acquisition. Constructivism is a perspective that suggests people construct their own understanding and knowledge of the world through experiencing things and reflecting on those experiences (Roblyer & Doering, 2013). When individuals encounter new experiences, they reconcile them with previous ideas or experiences, which may alter their existing belief, or discard the new information as irrelevant. Constructivism is not in itself a pedagogy but an epistemological category of learning theories that informs teaching methods in education.

As opposed to objectivist theories of knowledge, a constructivist perspective sees meaning as imposed onto the world rather than extant in it (Swan, 2005). In other words, objectivists believe that meanings exist in the world awaiting to be discovered, while constructivists argue that we create and put meaning into the world. A constructivist approach to epistemology holds that meanings are created based on our constant interactions with the physical, mental, and social worlds we inhabit, and we negotiate those meanings by building and adjusting our internal knowledge structure and organizing our perception and reflection on reality (Swan, 2005). To this end, many scholars agree that the works of John Dewey (1916), Jean Piaget (1952, 1957, 1973), Seymour Papert (1980, 1993), Lev Vygotsky (1978a, 1978b), and Jerome Bruner (1960, 1966, 1996) are among the most important building blocks for the development of constructivism as we know it today. The following paragraphs provide a brief summary of each of these theorists' contributions.

Dewey (1916) considered learning as a process of motivating students to pursue problems and identify ways to solve them. For this rationale, he recommends adapting a problem-solving approach to education. Dewey sees constructivism as a stepping stone to emphasizing students' ability in solving real-life problems (Huang, 2002). He suggests that knowledge is dynamic and as such learning should be a process of discovery.

Piaget's (1957, 1973) work emerged in the midst of behaviorist theories. As a biologist, Piaget studied how organisms reacted to the environments they inhabit, and applied that concept to children's learning. He maintained that children make sense of the world through the cognitive processing of environmental interactions and the corresponding construction of mental structures. According to Piaget, knowledge is abstracted from experience and formal reasoning can occur. He believed that humans undergo cognitive stages that help them to mature intellectually. This is why Piaget's theory is also known as cognitive constructivism, wherein learning is located in the mind of the individual and that mental construction is affected by the individual's interactions with the surrounding environment. Cognitive constructivism gives us the notion of knowledge organized internally as mental schemas. These mental schemes are referred to as models representing complex actions, causality, and relationships among ideas.

According to Swan (2005), social constructivism, which is derived from Vygotsky's (1978a, 1978b) work, is probably the most common version of constructivism. Vygotsky maintained that learning happens in the individual's mind but is also a result of social interactions with other individuals (not just the material world around them). Through communication and activities with others, Vygotsky believed that cognitive skills and patterns of thinking are products of the activities practiced in the social institutions of the culture in which individuals reside. Vygotsky also viewed the construction of meaning as a two-part, reciprocal process. Meanings are first enacted socially and then internalized individually. These internal conceptualizations then, in turn, guide the individual's social actions. Whereas Piaget is concerned with the internal development of schema, Vygotsky focused on the social construction of meaning, which he deemed as culturally determined. He believed that objects in the physical environment are not just what individuals perceive them to be, but rather affected by cultural traditions (Palincsar, 1998).

Bruner (1960, 1966, 1996) is another important figure in the constructivist view of education, who saw learning as an active process in which learners construct new ideas based on their current knowledge. For Bruner, technology is an influential part of instruction:

> Principal emphasis in education should be placed upon skills—skills in handling, in seeing and imaging, and in symbolic operations, particularly as these are related to the technologies that have made them so powerful in their human expression. (Bruner, 1966, p. 34)

Bruner's constructivist approach engages technologies as cognitive tools to help learners elaborate their ideas and engage in meaningful interactions with others.

Overall, a constructivist view of learning typically encourages students to employ active learning strategies such as experimentation and in-situ problem solving as a way of creating knowledge, and to reflect on their learning through dialogues and discussions. A constructivist teacher is usually concerned about the students' pre-existing concepts about a subject matter, how they negotiate meanings, and perceive new information through active grappling with the information to create knowledge. In the context of technology-enhanced learning, constructivism is concerned with how technologies might be employed to help learners express their mental structures and reflect on their constructions of knowledge (Simonson et al., 2014). Further, since constructivism emphasizes social learning, educational technologies are often evaluated for their capacity in facilitating collaboration and interactive learning.

3.1.2 Constructionism

Maker culture openly embraces constructionism, a theory of learning developed by Seymour Papert, a protégée of Jean Piaget. Whereas Piaget's constructivism is a theory of knowledge that sees learning as an active, social process in which students reconstruct knowledge rather than simply receive a transmission of knowledge from a teacher, Papert's constructionism is a theory of learning that suggests that the internal construction of knowledge is most readily achieved when the student is also engaged in the active construction of a personally meaningful and tangible product. For constructionists, emphasis is put on creating and discovering, and tapping into the learner's natural inclinations toward problem solving.

With active effort to differentiate his work from cognitive constructivism, Papert (1980, 1993) coined the term constructionism to highlight the particular role of external construction for internal (mental) construction of ideas and knowledge. Papert and other constructionist theorists contend that computer technologies have the ability to support learning by representing abstract ideas in concrete and malleable forms. They support the notion that computer-based constructions can make abstract concepts more accessible—and more importantly—readily internalized as mental schema so to lead changes in mental knowledge structures. Papert's constructionism is useful as a stepping stone in theorizing the use of computer technology as instructional tools in education.

Arguably, maker education stems out of both social constructivism and constructionism, where exploring, tinkering, and building are essential to the learning process. These elements can be built into the curriculum, where play and experiment are encouraged as processes of inquiry:

> From constructivist theories of psychology, we take a view of learning as a reconstruction rather than as a transmission of knowledge. Then we extend the idea of manipulative materials to the idea that learning is most effective when part of an activity the learner experiences is constructing a meaningful product. (Sabelli, 2008, p. 193)

The "meaningful" part of a maker approach to pedagogy acknowledges that the power of making something comes from the learner's question or impulse and is not imposed from the outside. This empowers learners to connect with everything they know, feel, and wonder, stretching themselves into learning new things, and liberating them from their dependency on being taught (Blikstein, Martinez, & Pang, 2015). This approach also stresses that students learn best by making tangible objects through authentic, real life learning opportunities that allow for a guided, collaborative process which incorporates peer feedback. As such, maker approach to education is tied holistically to constructivist-constructionist learning wherein construction and constructive reflection are concurrent practices that determine meaningful learning.

3.2 Social learning and collaboration in making

The culture of a makerspace, as noted by Andrew R. Schrock (2014), is focused on a flexible "openness" that supports its members as they move from "peripheral participants" to potentially "longstanding members engaged in ongoing projects" (p. 17). Social constructivists in writing studies believe "individual writers compose not in isolation but as members of communities whose discursive practices constrain the ways they structure meaning" (Nystrand et al., 1993, p. 289). The primary tenet behind this learning theory is that social interaction and participation, particularly with instructors, peers, and other members of the knowledge community, have a significant impact on learning (Chism, 2006; Lave & Wenger, 1991; Wenger, 1998). A number of scholars (Beichner et al., 2007; Bruffee, 1998; Panitz, 1999) have noted the importance of peer interaction and collaborative learning in higher education. Jean Lave (1991) has contended, "learning, thinking, and knowing are relations among people engaged in activity in, with, and arising from the socially and culturally structured world" (p. 67). Within composition studies, Karen Burke LeFevre (1987) has argued that invention should not be seen just as the private act of an individual writer. Both learning and writing are pervasively affected by the individual's relationships to others through language and social actions.

The advances in writing technology further bolster collaboration. As James Porter (2009) notes, "The computer plus the internet and the World Wide Web provide publishing capacity to the individual writer" (p. 219). The individual writer's capacity is motivated by social impulses: "people write because they want to interact, to share, to learn, to play, to feel valued, and to help others. And that drive to interact socially is a key feature of the new digital era" (Porter, 2009, p. 219). Along with the access to new media, a maker pedagogy would inspire collective creativity through peer-to-peer learning.

Over the last 30 years, research in writing studies and TPC on collaboration and collaborative writing has generated a body of scholarship with broad conceptions of collaboration, groups, and team-based learning (Allen et al., 1987; Ede & Lunsford, 1984, 1985, 1990, 2001, 2009; Lunsford & Ede, 2012; Bruffee, 1998). Ede & Lunsford's (1990) groundbreaking work has demonstrated that writing is intrinsically collaborative; years later, they discuss the relationship of collaboration with how scholars consider authorship (Lunsford & Ede, 2001) as well as its relationship with engaging audiences and the need to teach the concept of audience and acts of participatory communication (2009). Kenneth Bruffee (1984, 1998) emphasizes the usefulness of conversation and collaborative learning in writing pedagogy. Isabelle Thompson (2001) argues that "collaboration as a research issue and as practice seems firmly rooted in technical communication as a discipline" (p. 167). Ann Hill Duin and Rebecca Burnett's (1993) call for "additional research about collaboration in technical communication … to enable our discipline to eventually verify or replace lore in the classroom and the workplace" in the first special issue of *Technical Communication Quarterly* (*TCQ*) represents an important milepost. Following that *TCQ* special issue, Rebecca Burnett, ChristiannaWhite, & Ann Hill Duin (1997) identified evolving definitions of collaboration in technical communication, noting "contextual complications" (p. 136) involving participants with unequal commitments, time, and energy devoted to a task; different group structures; and face-to-face or computer-mediated interaction. Sally Henschel and Lisa Meloncon (2014) push for a similarly collaborative shift. They state that "even though TPC programs maintain specific strengths tied to faculty expertise and to local situations, programs should be embracing common conceptual and practical skill sets that will prepare students to become successful professionals" (p. 22).

In "The Impact of the Internet and Digital Technologies on Teaching and Research in Technical Communication," Laura Gurak and Ann Hill Duin (2004) contend that emerging digital technologies foster collaboration in TPC pedagogy and research. Powered by open access and open collaborative tools, makerspaces can be vigorous hubs of learning where individuals come to share ideas and work on projects together. For TPC, the maker approach invites learners to come out from their silo workspaces and combine resources to tackle complex communicative issues. Such tendency is deemed favorable by public and private sectors today where collective intelligence (Levy, 2000) is considered valuable in social capital. Lee-Ann Kastman Breuch in her book, *Involving* *the Audience* (2018), demonstrates the values and challenges of such complex collaboration with public stakeholders through cases of social media communication. In short, to integrate collaborative learning in TPC education is to acculturate learners into their future work environments, where collaboration and cross-functional teams are already commonplace (Lunsford & Ede, 2011).

3.3 Multimodality

> *Making is fundamental to what is means to be human. We must make, create, and express ourselves to feel whole. — Mark Hatch (2013, p. 11)*

> *A composition is an expression of relationships—between parts and parts, between parts and whole, between the visual and the verbal, between text and context, between reader and composer, between what is intended and is unpacked, between hope and realization. And, ultimately, between human beings. — Kathleen Blake Yancey (cited in Shipka, 2011, n.p.)*

To segue into the literature on multimodality, I start with two different voices above. While they come from quite distinctive domains (popular vs. academic), both Hatch and Yancey share a concern with the role of making in our lives—beyond just materialistic purposes. Making is fundamentally human, and it has been a trend in our field (composition particularly) to study how we could teach writers to communicate more holistically and humanly through multimodal means and genres. So, the tenets of maker culture might serve to inform theories of multimodal composition. Interestingly, in my review of literature on multimodality, I find multiple perspectives to which multimodal composition and multimodal literacy could be taught. I see this as an important observation and opportunity to expand our understanding of multimodality and multimodal literacy through making. A maker pedagogy would serve as a bridge across these perspectives, and consolidate the intersections of these ways of understanding multimodality. Below I provide a brief overview of these perspectives.

3.3.1 Locating a definition of multimodality

The term "multimodal" is used by the New London Group (Cope & Kalantzis, 2000; Kress, 2000, 2003, 2005, 2010; Kress & van Leeuwen, 1996, 2001) to indicate the range of modalities—printed words, still and moving images, sound, speech, and music, color—that authors combine as they design texts. In "Thinking about Multimodality," Pamela Takayoshi and Cynthia Selfe (2007) define multimodal texts as documents we see in digital environments that use multiple modalities to convey meaning. Shipka (2013), however, sees multimodal composing as something beyond just the print-and-digital dichotomy. In Theresa Dark and W. Douglas Baker's (2015) interview with Shipka, Shipka revealed that she positions her work quite differently "than those who teach multigenre or new media texts because her students often work with three-dimensional texts and live performances instead of traditional paper or electronic ones" (p. 75). Jason Palmeri (2012) also argues that equating multimodality with just the digital gives students a falsely narrow sense of the complexity of multimodal experience. Thankfully, our field's approaches are changing. While words and visuals (still and moving images) are most commonly employed in multimodal composition, aurality is slowly coming into the limelight in recent scholarship (see Selfe, 2009 on aural composing; Comstock & Hocks, 2006 on sonic literacy; VanKooten, 2016 on choric sound and writing; and Ceraso, 2014, 2018 on multimodal listening). Furthermore, thanks to advances in human-computer interaction (HCI) technologies, greater attention are given today to multisensory (emphases on haptic and kinesthetic) experiences of composing—leading to new scholarship on embodiment and materiality in multimodal composition (Haas & Witte, 2001; Arola & Wysocki, 2012; Rifenburg, 2014; Rhodes & Alexander, 2014). I will revisit the notion of embodiment in the following pages.

Evidently, writing studies has yet to arrive at a common definition for multimodality; but for the purpose of this work, I am going to assume an expansive approach to multimodality that treats multimodal meaning-making as engaged, rhetorical, and embodied practices, and that sees multimodal texts as an assemblage of symbols, signs, and signings in more than one mode of persuasion and/or expression. The goal of multimodality, as I see it, is effective communication.

3.3.2 Rhetorical awareness of multimodality

Given our field's rootedness in the rhetorical tradition, it is not surprising to find the majority of multimodal theories crediting rhetorical theories for informing multimodality. In reviewing the influence of classical rhetoric on multimodal theories in technical communication, Andrew Bourelle, Tiffany Bourelle, and Natasha Jones (2015) contend that the rhetorical canons—invention, arrangement, style, delivery, and memory––are the most often foundation used to develop pedagogical framework for teaching multimodality in TPC courses. Although Collin Brooke (2009) has argued that the rhetorical canons have limited impact in the digital age of technical communication, Bourelle, Bourelle, and Jones (2015) highlight that this limited impact is "due to a misuse or misunderstanding of the canons (p. 307). Bourelle and colleagues (2015), like many scholars in rhetoric and technical communication, believe that rhetorical theories provide useful heuristics for instructors teaching multimodality and for students composing using modes beyond just printed words: "Multimodality and traditional technical communication tenets need to be taught in conjunction. It should be made clear to students that the practical technical communication skills that they are learning are applicable across technological formats" (p. 322).

Certainly, building off the rhetorical tradition for technical communication pedagogy has been a common practice. In "Layered Literacies: A Theoretical Framework for Technical Communication Pedagogy," Kelli Cargile Cook (2002) advocates for a rhetorically grounded design of TPC pedagogy even in the age of digital literacy. The key difference in her layered framework, compared to typical pedagogical frameworks, is to teach the layers of literacies—basic, rhetorical, social, technological, ethical, and critical––in combination rather than isolated literacy. Rhetorical literacy should be viewed as a multifaceted knowledge that integrates the other layers of literacy, allowing students to demonstrate them—such as technological literacy, where students would decide what tools are best to use for creating meaning within the context of their audience, purpose, and writing situation. In agreement with Cargile Cook's argument, I see the need to base multimodal pedagogical frameworks on rhetorical strategies of composing (and making). Just as Tarez Graban, Colin Charlton, and Jonikka Charlton (2013) have urged us in Tracey Bowen and Carl Whithaus's *Multimodal Literacies and Emerging Genres* (2013), we should "keep it [our penchant for innovation] rhetorical" (p. 252).

Further, Cargile Cook (2002) points out an important exigence for building updated frameworks that meet the changing demands of the TPC workplace: "[That] workplace writers need a repertoire of complex and interrelated skills to be successful. Instructors can no longer simply provide students with opportunities to discuss form, discourse types, or the writing process. Such discussions must be further supplemented with activities that promote collaborative team-building skills and technology use and critique" (p. 8). This should serve as a baseline criteria for any TPC pedagogical framework we try to devise.

3.3.3 Multimodal literacy as multilingual and multiliteracies

Recently, our field has been engaging in conversations about the increased connections between multilingualism and multimodality. For example, at the 2014 CCCC, Min-Zhan Lu, Anis Bawarshi, Nancy Bou Ayash, Juan Guerra, Bruce Horner, and Cynthia Selfe (F.38 "Rethinking difference in composing composition" at NCTE 2014) situated the future of writing instruction in translingual, multimodal practices and pedagogies. In this panel, Selfe and Horner highlighted the importance of moving beyond a "single language/single modality" approach to writing instruction, to account for "the increasing, and increasingly undeniable, traffic among peoples and languages" reflected in our classrooms. Important conversations stemming from this work are reflected in both the NCTE Position Statement on Multimodal Literacies (NCTE, 2005) and the Resolution on Students' Rights to their Own Language (NCTE, 1974). In essence, pedagogies that push writing beyond a single-language, single-mode model, and that acknowledge the historical and cultural foundations of linguistic diversity, are increasingly promoted to help students develop rhetorical dexterity to successfully communicate across a wide range of contexts.

Multimodal literacy has also been treated with social considerations of design, power, and action. In his landmark book, *Multiliteracies for a Digital Age*, Stuart Selber (2004) highlights three kinds of technology literacies: functional, critical, and rhetorical. Through a lens of layered literacies similar to that of Cargile Cook (2002), Selber takes up the New London Group's term, "multiliteracies" (1996) to guide writing instructors and writing program administrators in developing full-scale computer-support composition programs that emphasize his three highlighted literacies. Selber considers technology-driven composing practices from a humanistic perspective, thus putting the pedagogy of multimodality and computer literacy back to the realm of the critical and socio-political. For those with predominantly instrumental view of digital literacy and multimodality, Selber's emphasis of the social scene for computer-based writing offers a contextual view of the composing technology.

3.3.4 Modes and semiotics

Much of the current writing studies scholarship on multimodality stem from literature on the visual mode of scientific and technical communication. For example, Charles Bazerman (1981), in his analysis of Watson and Crick's landmark article on the structure of DNA, notes their use of a diagram on their first page in order to provide "the geometrical essence of the solution" (p. 368). In their book on visual design, Gunther Kress and Theo van Leeuwen (1996) point out that visuals play a prominent role in scientific meaning making. Jeanne Fahnestock's (2003) numerous scientific examples in her analysis of visual and verbal parallelism reinforce the importance of the visual mode for scientific discourse. She finds, for example, that "tabular presentation of instances, examples, or data sets that would otherwise require parallel or repetitive phrasing are the norm in scientific discourse" (Fahnestock, 2003, p. 140). In their work on multimodal semiotic analysis, Anthony Baldry and Paul Thibault (2010) examine "meaning compression" in scientific writing, arguing that "scientific texts have always combined and integrated language and visual images in the making of the specialist meanings of scientific discourses" (p. 70). More recently, Jonathan Buehl (2016) looks at scientific arguments through the lens of multimodal process and examines the rhetorical problems in creating multimodal artifacts—mainly visuals—in an age of digital circulation. Taken together, these studies provide a foundation to Gunther Kress's (2010) articulation of mode as a semiotic resource, whereby difference modes offer distinctive affordances. For instance, as Kress (2000) illustrates:

> Image is founded on the *logic of display in space*; writing (and speech even more so) is founded on the *logic of succession in time*. Image is spatial and nonsequential; writing and speech are temporal and sequential. That is a profound difference, and its consequences for representation and communication are now beginning to emerge in this semiotic revolution. (p. 339, emphases original)

What Kress (2000) has pointed out is part of an obvious phenomenon that humans have always learned to communicate through multiple sign systems or modes, each of which offers a distinctive way of making meaning (Kress & Bezemer, 2008). To this end, Glynda Hull and Mark Nelson (2005) state, "A multimodal text can create a different system of signification, one that transcends the collective contribution of its constituent parts. More simply put, multimodality can afford, not just a new way to make meaning, but a different kind of meaning" (p. 225). This is a crucial concept to bear for understanding the workings and meanings of multimodal texts.

3.3.5 Medium/media and materiality

Besides rhetorical theory, scholars of digital media and writing have focused primarily, although not exclusively, on medium theories (many citing McLuhan, 1964/1994) and the electronic/digital composing environment when studying multimodality, such as the early CD-ROM, word-processing interface, presentation slideware, blogs, websites, and more recently, code programming and project management platforms (Bolter & Grusin, 2000; Bolter, 2001; also see Hart-Davidson et al., 2005; Eyman, 2015). In these studies, the terms "multimedia" and "multimodal" have been used interchangeably. While both describe the multifaceted composing experience, they are independent of and interdependent with each other. Claire Lauer (2009) shows the difference:

> Modes can be understood as ways of representing information, or the semiotic channels we use to compose a text (Kress & van Leeuwen, 2001). Examples of modes include words, sounds, still and moving images, animation and color. Media, on the other hand, are the "tools and material resources" used to produce and disseminate texts (p. 22). Examples of media include books, radio, television, computers, paint brush and canvas, and human voices. (p. 227)

This distinction is important for the conceptualization of multimodality because it helps writing studies scholars to determine what to focus on in teaching and research. In the classroom, it helps instructors to allocate time for teaching specific composing technology (like Microsoft PowerPoint, Adobe InDesign) and composing with certain modalities (words, sounds, etc.).

The medium/media approach to multimodality tends to come hand-in-hand with conversations about the materiality of composition. In multimodal theories, materiality tends to refer to the observation of modes being taken to be the product of a maker shaping physical materials into meaningful artifacts. Matthew Davis and Kathleen Yancey (2014), in their discussing the role of materiality on assessment of multimodal texts, cite Lester Faigley (1999) for his argument about modality and materiality in multimodality:

> Images and words have long coexisted on the printed page and in manuscripts, but relatively few people possessed the resources to exploit the rhetorical potential of images combined with words. My argument is that literacy has **always** been a material, multimedia construct but we only now are becoming aware of this multidimensionality and materiality because computer technologies have made it

> possible for many people to produce and publish multimedia presentations. (p. 175, emphasis original)

Christina Haas (1996) has particularly pointed out the material dimensions of literacy and writing, with the term "material" referring to anything that possesses mass or matter, and which uses physical space. For multimodality, this includes any tools or resources that cross between the composer and his or her artifacts. In this sense, the material elements of the composing space—the pencils, desks, chairs, screens, keyboards, and other literacy materials—function as heuristics for learning. The connections between materials, users/composers, and the literacy knowledge in the composing environment are often mapped onto the socio-material conditions of learning as a way of problematizing their relations to the wider societal issues. In our field, scholars have been increasingly relying on activity and circulation theories to study the mediating power of tools as tied to knowledge making and dissemination (see Prior & Shipka, 2003; Trimbur, 2000). These socio-cultural and historical approaches to composing and multimodality emphasize the active and dynamic role of tangible materials, and the vitality of their interplay with learning and writing.

3.3.6 Embodiment and spatial relations

In "Polymorphous Perversity in Texts," Johndan Johnson-Eilola (2012) makes an argument that multimodal theories can be expanded by seeing multimodal texts as multidimensional texts—beyond just signs and symbols. Johnson-Eilola challenges us to think about how we take pleasure in texts by interacting with them through fragmentation, unmaking, and remaking:

> I want to ask what happens when we begin to take less-authorized, polymorphously perverse pleasure in our texts, when we begin to treat texts less as objects out there and more as objects that we—literally—transgress the boundaries of, fragment, unmake, and remake. (Johnson-Eilola, 2012, n.p.)

Pointing directly at maker culture, Johnson-Eilola highlights the importance of remix/remake in text ownership: "If you can re-make an object, you don't really own it" (2012, n.p.). More importantly, Johnson-Eilola's argument is an example of recent development in multimodal theories that focuses on the embodied experience of modalities. In discussing the possibility of teaching "multimodal listening" in composition, Steph Ceraso (2014) argues that "alongside and in addition to semiotic approaches to multimodality, it is necessary to address the affective, embodied, *lived* experience of multimodality in more explicit ways" (p. 104; emphasis original). For multimodality, embodiment is how the body—corporeal, representational, gendered, experiential, or physical—interacts with the rest of the constituents in the multimodal composing process, such as tools, resources, media practices, physical spaces, and social environments. In digital media spaces, embodiment usually manifests in representations such as avatars or perceived presence in immersive virtual environments. In physical or mixed reality (virtual integrated in the real), embodiment could be studied in terms of interdependencies between social agents and between people and tools/machines, gestural communication, etc. When advancing technologies, especially virtual reality and artificial intelligence, the lines between the real and the virtual is increasingly blurred, and what that means for multimodal composing is greater complexity in the conceptions of singular as well as combined modalities, particularly when they are mapped onto the time-space dimension.

3.3.7 The "Maker" connection to multimodal theories and rhetorical perspectives

In "Composing the Carpenter's Workshop," James Brown and Nathaniel Rivers (2013) envision an object-oriented future for writing studies, one where students compose objects like puzzles and glass sculptures with ads and packaging for their objects. This future that Brown and Rivers imagine is partially an extension of Shipka's (2011) multimodal composition theory and partially an enactment of Ian Bogost's (2012) call to include *all matter* and not just "written matter" in humanities scholarship. Increasingly, writing studies scholarship is calling for attention to the rhetorical powers of everyday objects beyond written artifacts. Scot Barnett and Casey Boyle (2017) in their edited volume, *Rhetoric, through Everyday Things*, challenge the notion that inanimate objects are passive tools and argue that nonhuman things can be rhetorical agents that persuade human activities. For this reason, writing in the 21st century should reflect a consideration for the material dimension of rhetoric.

In 2012, the Council of Writing Program Administrators (CWPA) began revising the Outcomes Statement (which originally named five values traditionally associated with academic writing: rhetorical knowledge; critical thinking, reading, and writing; flexible writing processes; and knowledge of convention) to better account for the increasing presence of multimodal composing in writing classes—evidence that new materialism is gaining prominence in our field. As David Sheridan (2010) writes, "three-dimensional objects do indeed function rhetorically and may even possess their own distinctive rhetorical power. In fact, three-dimensional objects appear to play a unique role in fashioning culture itself" (p. 255). Given these affordances, a maker pedagogy, focusing on inventing and interacting with objects, might point us to a dimension of composition that is less explored in traditional writing studies, one that better tackles the wicked problem of teaching writing than print-driven methods.

In addition to the materialist dimension, making presents opportunities for augmenting our rhetorical canons. Particularly, making challenges us to reconsider the viability of invention and delivery in an age of rapid innovation. For TPC, we can study how prototyping changes the way we traditionally think of creation and final products. Failures and incompletions are common occurrences in the makerspaces; how do they help us rethink creativity? How might that affect TPC practices in the workplace and technical communicators' collaboration with designers and developers? These are questions I explore as part of my study.

3.4 Design thinking and writing studies

Coming to a full circle, I close this literature review with the concept of design thinking in writing studies and TPC contexts. Design thinking (Figure 7), although never truly has a fixed definition, is a human-centered, innovative process involving five phases: empathize, define, ideate, prototype, and test (Hasso Plattner Institute of Design at Stanford, n.d.). Design thinking scholars typically look to four seminal texts that laid out that basic concepts of design thinking: Bryan Lawson's *How Designers Think* (1980), Robert McKim's *Experiences in Visual Thinking* (1980), Peter Rowe's *Design Thinking* (1987), and Richard Buchanan's "Wicked Problems in Design Thinking" (1992). Historians can easily make a connection between the growth of the design thinking movement and the rapid evolution of personal computers and mobile devices in the 1980s. Those at Apple, Xerox, IBM, and Hasso Plattner Institute of Design (also known as the Stanford d.school) are often held up as pioneers of the design thinking process.

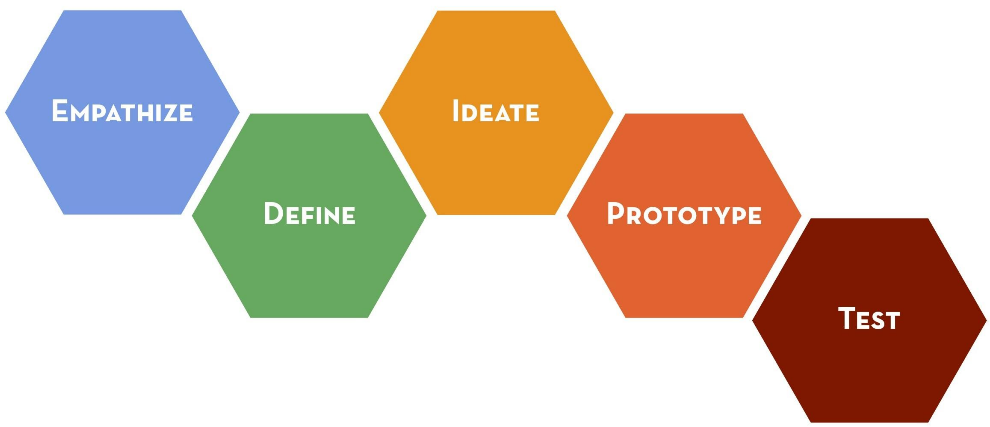

Figure 7. The basic model of design thinking by the Stanford d.school.

The link between multimodality and design thinking is almost inevitable. In "What Can Design Thinking Offer Writing Studies," James Purdy (2014) argues that "design thinking offers a useful approach for tackling 'wicked' multimodal/multimedia composing tasks" (p. 614). Purdy contends that design thinking forces writing studies to move beyond print based conditions and explore other modalities as available means of meaning making. "Invoking design," Purdy writes, "can serve to answer Jody Shipka's call for the discipline to focus on all communicative practices, not just writing" (2013, p. 73).

Published in *College Composition and Communication (CCC)* the same year, Leverenz (2014) also advocates for design thinking as a teaching framework and composing process for multimodal texts: "... it eliminates the question of how to fit multimodal composing into writing classes since it focuses on designing solutions to problems rather than creating forms for their own sake" (p. 3). As Leverenz points out, arguments for the place of design thinking in writing studies are not new, they began as early as 1989 with Charles Kostelnick's *CCC* article, "Process Paradigm in Design and Composition: Affinities and Directions," where he critiqued the then buzzword, "process pedagogy," and offer design as a counterpart to the writing process. Almost 20 years later, Richard Marback (2009) again offer design thinking as a "new" paradigm for composition. It can be inferred, by the lack of scholarship between Kostelnick (1989) and Marback (2009), that our field—composition particularly—has been skeptical about the concept of design as a solution for writing problems. However, given the increased attention given to multimodality and multimodal composition, writing studies as a whole is becoming more accepting of design thinking models and approaches to composing, especially when it involves multimedia technology and "wicked" communicative problems that require solutions beyond text-only mediation.

Jennifer Bay, Richard Johnson-Sheehan, and Devon Cook (2018) encourage TPC program administrators to introduce principles and methods of design thinking in technical communication service courses to let students practice applying these concepts in real-world entrepreneurial situations. Bay et al. argue that design thinking is suitable for introducing students to other TPC concepts such as audience/user-centered design, usability, collaboration, and mentoring. More importantly, design thinking helps reinvigorate departments such as English, Rhetoric, and Communications that are increasingly challenged to respond to rapid changes in the economy and our students' career interests. In their own words, Bay et al. (2018) maintain,

> Technical communication must evolve to meet these new challenges. We must teach our students how to have empathy for users, peers, and stakeholders, just as we must have empathy for the needs of our students. We must define educational problems from our students' points of view, not our own, and we need to ideate

> those problems by reframing them and incorporating new technology. We need to prototype new assignments and new activities and then do testing to see which ones work. (p. 193)

This dissertation is a response to Bay et al.'s call. I seek to update our approaches to multimodal composing and problem solving in technical communication by reviving social learning theories in our pedagogy, expanding the means and definitions of multimodality, and introducing new elements such as design thinking into our professional practice.

3.5 Chapter summary

This chapter focuses on four main tenets of making found in educational theories and writing studies that support an investigation of a maker approach to TPC pedagogy: constructionist and constructivist learning, collaborative learning, multimodality, and design thinking. From reviewing the key literature across these domains, I have found that "writing" in the 21st century can benefit from being seen through the lens of educational theories as informed by Papert, Vygotsky, and Bruner. These theories, while under-utilized in our field today, can be used to guide writing pedagogy and emergent learning strategies, such as the infusion of maker culture. Based on the growing conversations around multimodal composition and technological literacy, making seems to help bridge the void between students' consumption and production of multimodal texts. The current scholarship in design thinking signals a shifting paradigm for writing pedagogy from verbal to extra-verbal communication. Such change, combined with the need for the academy to remain relevant to workplace and social practices, creates an exigence of a study of making as a new approach to teaching and learning in new-age higher education. I present this study and its research design in the following chapter.

CHAPTER 4
Studying Makerspaces and Making: Research Methods

This chapter details the methodological design of this dissertation. I begin by stating the overarching and supporting research questions derived from the exigence highlighted in my literature review. Then, I describe the two-part data collection and analysis methods for this study in order to address its research questions.

4.1 Research questions

As demonstrated through the previous chapters, we need to update our pedagogy to infuse multimodal literacies into TPC instruction so students can learn to solve wicked problems using relevant technologies and through constructivist and constructionist practices. With this as a guidepost, this dissertation research is concerned with the viability of design thinking and the maker approach to TPC pedagogy as a way to address issues with multimodal literacy and its delivery. To this end, I pose the following overarching research question:

> **How do students compose and create multimodal solutions to address complex problems in technology-enhanced maker practices informed by design thinking?**

An underlying warrant to this question is that students will be actively creating and building as part of their experience in the class. My study is interested in understanding the ways in which students create solutions to address the wicked problems that they see as important. This can be observed through the processes of making and works produced by students, individually and collaboratively, in the TPC classroom. The design of this learning experience is modeled after maker practices and current configurations of academic makerspaces. In this study, students are given rapid-prototyping tools and technological support—such as an academic technologist or IT unit—to create, prototype, and test their solutions. In order to answer the above central research question, I ask three supporting questions:

1. How are makerspaces set up and operated in higher education settings?
2. How do students use a makerspace to compose and create multimodal artifacts?
3. How might we teach TPC through making and makerspaces?

Through this research, I should identify the pedagogical viability of maker practices in TPC pedagogy. The goal of this dissertation is to present a framework that TPC instructors can use to design courses that produce students with a maker mindset. To do so, I first observe selected makerspaces to understand their ways of operation and how makers interact within those spaces. Then, I develop and deploy a maker-infused TPC course to study its benefits and limitations.

4.2 Research methodology and design

The nature of this dissertation project is unique for two reasons. First, it examines where learning takes place through the theoretical constructs of constructivism and constructionism. While the use of formal learning theories in writing studies research is not uncommon, this project sheds new light onto the usefulness of education theories for writing and TPC pedagogy through updated technologies in makerspaces.

Second, the two-step approach this project takes to study academic makerspaces and construct a teaching framework for TPC pedagogy creates a well-rounded investigation of the viability of the Maker Movement for higher learning. In all of the current studies I have reviewed that are researching the potentials of makerspaces in higher education—including latest theses and dissertations from our field that directly address makerspaces (see Sherrill, 2014; Shivers-McNair, 2017; West-Puckett, 2017), researchers are *either* performing an ethnographic or case study of a makerspace *or* attempting to test a teaching model by deploying it and assessing if effectiveness in the classroom. This project combines the two; I first observe selected makerspaces in terms of how they operate and how makers utilize the space for their projects, and then create a pedagogy for TPC using such observation. Greater emphasis is placed on the second part of this study, where the maker-based course is evaluated.

As mentioned above, this study is made up of two parts. Part one consists of three observations of selected makerspaces in academic settings. Part two is a pedagogical case study, which follows the deployment of a maker-based TPC course designed using the findings from the first part of this study. Below is an overview of these two parts.

Part 1: Makerspace site observations

1. Identify and locate key academic makerspaces across the country.
2. Perform site observations on three academic makerspaces—analysis of setup, workflow and process, learning objectives and outcomes, effectiveness, etc.
3. Identify common/key themes across all site observations.

Part 2: Case study of a maker-based course

4. Develop and deliver a TPC course using key findings from site observations.
5. Evaluate benefits and limitations of the maker-based course.
6. Refine framework and recommend future deployments and studies.

Figure 8 shows a visual schematic of this study's methodology. Note that leading up to the makerspace observations in Part 1, I have performed a focused literature review as well as networking with those who are in the business of building and maintaining makerspaces in academic settings. As part of the networking effort, I have connected with makerspace designers, academic technologists, librarians, mechanical engineers, and student groups (such as Tesla Works[18], Design U[19], and 10,000 Makes[20] at University of Minnesota). I have also participated in the 2017 International Symposium on Academic

[18] See https://www.teslaworks.net/
[19] See https://www.designu-mn.org/
[20] See https://www.10000makes.com/

Makerspaces[21] where academic and non-academic staff (librarians, makerspace directors) interested in makerspaces came together to discuss emerging issues in these spaces.

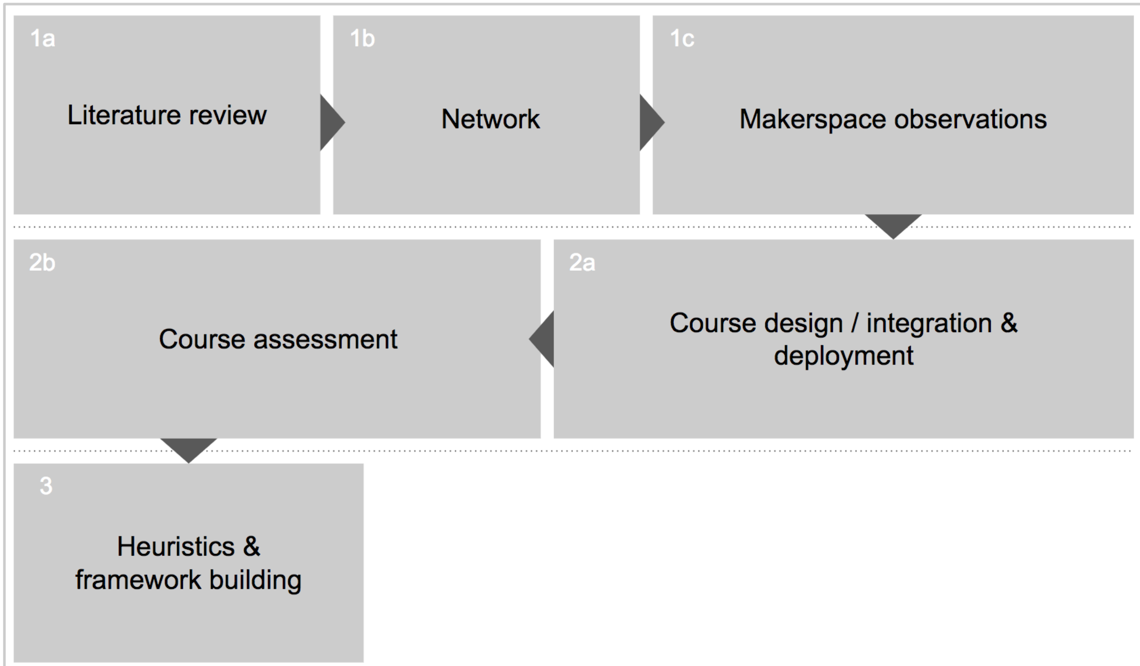

Figure 8. The schematic of this project's research methods.

4.3 Descriptions for part 1 of the study: Makerspace site observations

4.3.1 Site selection

To ensure the validity of results, I have chosen to observe three sites to find out how they are operated and used. I began with Thomas Barrett and colleagues' (2015) review of university (academic) makerspaces. I have specifically looked for three types of operational models: student-run makerspaces, faculty-run makerspaces, and makerspaces supported by specific non-academic staff. From there I chose two makerspaces, namely Think[box] and Invention Studio. The third makerspace, Anderson

[21] The 2nd International Symposium on Academic Makerspaces was hosted by Case Western Reserve University in September 2017. I presented on this dissertation project there. See conference website: https://isam2017.hemi-makers.org/

Labs, is at the University of Minnesota—Twin Cities. Table 1 below shows the selected makerspaces observed in part one of this study, their university affiliation, and operational model[22].

Table 1.

Makerspaces selected for observation.

Makerspace	**University Affiliation**	**Operational Model**
Anderson Labs[23]	University of Minnesota—Twin Cities	Faculty & staff run
Think[box][24]	Case Western University	Staff run
Invention Studio[25]	Georgia Tech	Student run

All three of these selected makerspaces have two things in common. First, they are all comprehensive facilities[26] that afford their respective makers with tools, technologies, and talent resources (managers, supervisors, tutors, volunteers) that help facilitate makers' success. Second, all three makerspaces employ open membership. This means that any students and faculty members within which institution the makerspace is housed can freely utilize the space without needing to pay a fee or acquire certain academic status.

4.3.2 Site observation procedure

The observation of makerspaces took place in the following chronology:

May 2017: Anderson Labs at University of Minnesota—Twin Cities

July 2017: Invention Studio at Georgia Tech

September 2017: Think[box] at Case Western Reserve University

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[22] I will address differences related to these three operational models in the next chapter.
[23] See https://cse.umn.edu/college/anderson-student-innovation-labs
[24] See http://engineering.case.edu/sears-thinkbox
[25] See http://inventionstudio.gatech.edu/about/
[26] There are facilities that claim to be makerspaces even though they provide only a 3D printer and some other electronic circuitry tools. A comprehensive facility should be able to support most, if not all, productive efforts of a makers' creative endeavor.

I first contacted the managers of these makerspaces via emails and phone calls. In these initial contacts, I negotiated with the makerspace managers about the goal of my visit, scope of observation, and interaction with their users. Since this study was approved by the University of Minnesota's Institutional Review Board (IRB) as an exempt, I had no trouble observing the Anderson Labs—which served as a pilot study to this project. To gain access to Georgia Tech's Invention Studio, I connected with the IRB administrators there in summer 2017 and had to provide all of my IRB documentations from the University of Minnesota for their own review. It took about a month before Georgia Tech's IRB agreed that my visit was considered an "exempt" from human subject research regulations. Thankfully, the process was simpler with Case Western Reserve University. All I had to do was to show my exempt notice from the IRB at the University of Minnesota to the Think[box] managers and they approved my visit immediately.

Upon gaining consent to observe these sites, I arranged a meeting proper with the respective managers and determined the days and times to observe user interactions in their makerspace. My travels to Georgia Tech and Case Western Reserve University were partially supported by a summer grant awarded by the Department of Writing Studies.

4.3.3 Data collection

In her introduction to the different approaches to researching multimodality, Carey Jewitt (2009) outlines what she perceives to be the three central approaches within multimodality studies: the social-semiotic approach (Kress & van Leeuwen, 1996), the discourse analysis approach (O'Toole, 1994; O'Halloran, 1999, 2000, 2004), and the interaction analysis approach (Scollon & Scollon, 2003; Norris, 2004). While this research does not follow any of these approaches strictly, Part 1 of this study is modeled after Sigrid Norris's (2014) multimodal interaction analysis method, where tacit participation and mediated interactions are observed and analyzed. On her personal website, Norris explains her multimodal interaction analysis method:

> “When studying multimodal interactions, my focus is on the actions that individuals take. Some of these are lower-level actions (like turning a page in a magazine), some are higher-level actions (like having dinner or a conversation), and some are frozen actions, which are entailed in material objects (such as a cup of coffee and a pastry on a table—which tells us that somebody is having coffee; the layout of a room—which tells us that somebody arranged the furniture in a specific way; or a painting on a wall—which tells us that somebody placed it there)” (Norris, n.d.)

During my visits, I focused on the following: makerspace setup, workflow and process, student project learning objectives and outcomes, and effectiveness of the space for learning and making purposes. I spent at least two days at each site performing the observations and kept a personal journal to record field notes. Using Norris’s method, I recorded the ways users of the makerspaces interact and use the space to work on solutions to their problems. I also used video recording to capture footage of these interactions. These recordings were transcribed following each of my visits.

To understand how the selected makerspaces were utilized, I interviewed the makerspace managers and volunteers who play a key role in running the specific makerspace. I also spoke to students who were using the spaces for their projects. Doing so has allowed me to collect multiple voices to capture the essence of these makerspaces. At each makerspace, I interviewed two students and one to two non-student staff/managers. The interviews varied in length. The shortest interview was about 25 minutes and the longest at almost an hour. The average length is about 40 minutes. Table 2 provides a snapshot of the interviews at each makerspace.

Table 2.

Interviews conducted at each makerspace (student interviewee names are pseudonyms).

Makerspace	**Interviewees**	**Duration**
Anderson Labs (UMN)	Adam (student)	25 mins
	Mickey (student)	35 mins
	Ben (staff)	65 mins
Invention Studio (GA Tech)	Brian (student)	60 mins
	Teresa (student)	35 mins
	No name given (staff)	20 mins
Think[box] (Case Western)	Nicola (student)	45 mins
	Ryan (student)	40 mins
	Marcus & Ian (staff; together)	30 mins

4.3.4 Data analysis

I analyzed the transcribed field notes and interviews using a modified grounded theory analysis (GTA). According to Gary Evans (2013), a modified GTA is built upon the classic works of sociologists Barney Glaser and Anselm Strauss (1967), updated by Kathy Charmaz (2000, 2014) and supported by Tom Andrews (2012). Glaser and Strauss's (1967) model assumes no specific theoretical emphasis or preconceived research questions in the data collection, coding, and analysis processes. A modified GTA allows the researcher to apply theoretical constructs while analyzing codes. A modified GTA approach is appropriate for my project since I have research questions to begin with. Essentially, I first performed open and then focused coding of the field notes and interview transcriptions. Through comparison, I looked for the constructs of multimodality, design thinking process, and maker intersections.

4.4 Descriptions for part 2 of the study: Pedagogical case study

4.4.1 Course development

Upon completing the first two site observations, I developed a course informed by the themes emerged from on-site interviews and observations. These findings are elaborated in Chapter 5: Analysis of three makerspaces. The course consists of activities and evidence of learning (events, processes, and artifacts that can be observed and measured) that indicates growth in multimodal literacy.

4.4.2 Deployment procedure

The course in which I have developed with the findings from Part 1 was WRIT 3562W Technical and Professional Writing. This course is an upper-division writing course at the University of Minnesota with double writing-intensive designations. Students who enroll in this course are typically sophomores, juniors, or seniors who are required to take a writing-intensive course outside their major, or students who are majoring or minoring in Technical Writing and Communication. My pedagogical case study was performed in Fall 2017 semester (WRIT 3562W, Section 009), where 24 students and I met on Mondays, Wednesdays, and Fridays for 50 minutes each class session. Details regarding this course design are included in Chapter 6.

4.4.3 Data collection

In this second part of the research, data were collected using several methods, including student projects, qualitative interviews with students, and my own teaching notes. In the beginning of the semester, I informed the students about my intentions for observing their work as part of this study. Students were aware that this study was designated as "exempt" from review by the IRB at the University of Minnesota. All students then agreed to sign a consent form to enroll in this study. I did not encounter any student who did not want to participate in the study, so alternative assignments were unnecessary. Students were also informed they could withdraw from the study at any time. All students participated in the study until the end of the course.

Throughout the semester, I kept a running log of my teaching notes and personal memos to document emergent ideas and observations. I wrote about students' reactions to the beta maker pedagogy framework as well as my own attitude toward teaching making in the course. At the end of the semester, I asked six students to participate in qualitative interviews with me about their experiences with making in this course. To triangulate the types of data collected, I gathered all student projects completed in this course to evaluate the impact of the maker framework on students' learning outcomes. To ensure accuracy in my evaluation, I asked all students to complete a self-assessment using an online tool produced by our College of Liberal Arts called RATE (https://rate.umn.edu/). RATE walks students through the process of reflecting, articulating, translating, and evaluating (hence "RATE") of learning experiences as they relate to the Core Career Competencies defined by the college. These self-reported assessments of learning provides me with perspectives that align collegial student learning outcomes with the pedagogical goals of the maker pedagogy framework.

4.4.4 Data analysis

Similar to Part 1's analysis, all interviews and journal notes were analyzed using modified GTA methods. As for student projects, I evaluated them using heuristics modified from Yancey (1992), with an eye towards evidence of multimodal literacy gain, skills acquired, and quality of the final product. I used the student responses from RATE to juxtapose against the evaluations of student projects.

4.5 Chapter summary

This chapter has covered the methodological design of this study to answer its research questions. These questions, as informed by my literature review, seek to identify how a maker approach to teaching TPC could help cultivate multimodal literacy. Using a two-pronged investigation, this study looks at how students use making to create multimodal texts and address wicked problems through a writing course. I first conducted site observations at three makerspaces, followed by a pedagogical case study where I developed and deployed a maker-based course that is an upper-division writing-intensive technical and professional writing course. In the next chapter, I share the results from part one of this study by revealing findings from a comparative review of the three academic makerspaces named in this chapter.

CHAPTER 5
Analysis of Three Academic Makerspaces

This chapter reports the findings from my site observation of three academic makerspaces selected for this study. It addresses the two of three supporting research questions stated in the previous chapter: 1) How are makerspaces set up and operated in higher education settings? 2) How do students use a makerspace to compose and create multimodal artifacts?

In retrospect, my data collection process started as soon as I had identified and selected the makerspaces to visit, and gained consent to interact with the users in those spaces. Although I do not count any "studying" of the makerspaces before my visit as valid data for this project, I have gained useful knowledge about the mission, vision, values, and operations of these makerspaces from their respective websites before I even stepped foot into their spaces. I have also interacted with the managers of the three makerspaces through phone calls and emails; these exchanges have helped me understand how each space is managed and run[27].

In the previous chapter, I described the selection process of these sites: 1) they were reviewed as legitimate higher education makerspaces by Barrett et al. (2015), and 2) they fulfill two requirements about access and available resources. I spent two days at each site performing ethnographic observations at the space, understanding their users/makers and workflow. In the following sections, I begin with a technical introduction of each makerspace, followed by my findings on their respective setup, workflow and processes, user/maker experience, and key observations on each site. Then,

[27] A caveat about the timing of my visits: these site observations took place over the summer, thus the number of users in the makerspaces was significantly lower than the regular semester.

I perform a comparative analysis of the three makerspaces by highlighting their common features and unique elements.

5.1 Anderson Student Innovation Labs at University of Minnesota—Twin Cities

The Clifford I. and Nancy C. Anderson Student Innovation Labs (also known as Anderson Labs) are made up of three separate labs—Student Design Lab, Student Shop, and Student Machine Shop—all currently housed in the University of Minnesota's (UMN) College of Science and Engineering (CSE). The Anderson Labs are the first full-scale makerspace I have come across when starting this project. The 10,000 square feet facility was initially home to several wood and metal shops where engineering students practice wood and metalworking, welding, milling, and electronic circuitry. It was reimagined as a makerspace in 2016, after receiving a generous donation from Clifford and Nancy Anderson, with the addition of two new design and prototyping focused labs, and a major upgrade to an existing lab space[28]. The goal of this reimagined space is to focus on experiential learning and helping students to turn their design into reality.

I was introduced to the Anderson Labs by Jonathan Koffel, a health sciences librarian turned emerging technology and innovation strategist, when I was first exploring the concept of making and makerspace. Through initial introductions, I was put in contact with William Durfee, head of the mechanical engineering department and faculty sponsor for the Anderson Labs. Durfee then introduced me to two important individuals. The first is Ben Guengerich, the manager of Anderson Labs. Guengerich was an important informant in my study as he provided me with tours and detailed explanations of the function of the Anderson Labs. Given my "home field advantage," I was able to visit the labs several times on different occasions, unlike the other two makerspaces examined here where I only had one opportunity to visit each of them. The second individual Durfee introduced me to was Josh Halverson, a then-senior mechanical engineering student who was doing an honors thesis examining academic makerspaces. Halverson

[28] See news about the launch of the Anderson Labs here: https://cse.umn.edu/news-feature/new-cse-student-shops-inspire-student-innovation/

provided insightful perspectives on the uses of makerspaces from a student's point of view.

5.1.1 Setup of the Anderson Labs

The Anderson Labs are not all located in the same building. The Student Design Lab (ME 2-134) and Student Machine Shop (ME 176) are located in the Mechanical Engineering building, and the Student Shop (CIVE 335) is in the Civil Engineering building. There are underground tunnels that connect them.

The official reception of the Anderson Labs is the Student Design Lab (Figure 9), which is on the second floor of the Mechanical Engineering building located on the East Bank of UMN.

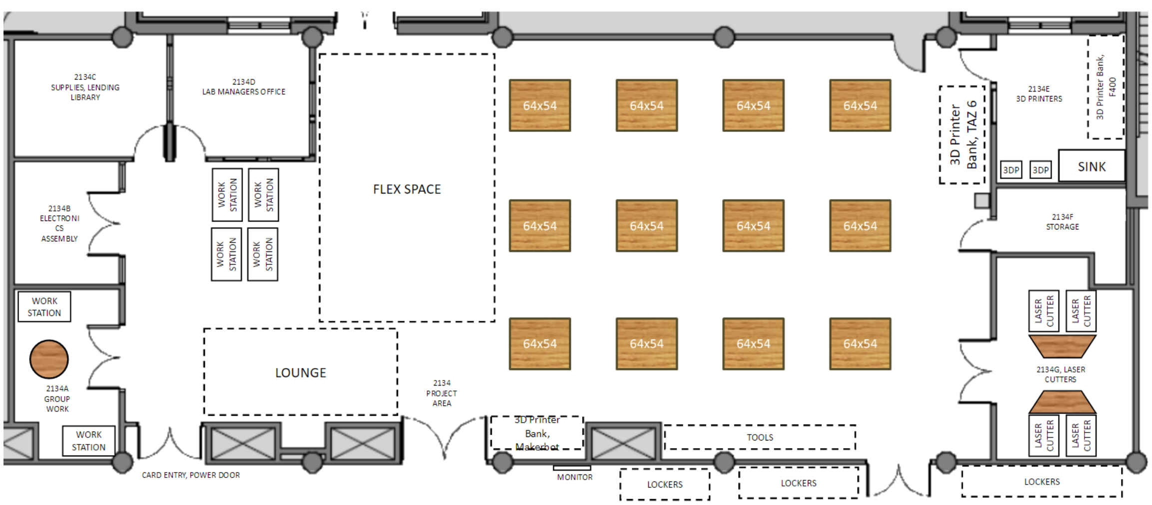

Figure 9. The Student Design Lab floor plan (courtesy of Ben Guengerich).

The Student Design Lab is a large workspace equipped with workbenches, tables, hand tools, power tools, laser cutters, computers, and 3D printers. The primary purpose of this lab is to allow students to test out their design through rapid prototyping and modeling. It also has open meeting pods with chairs and whiteboards that let students collaborate or discuss ideas (see Figures 10 and 11). The Student Design Lab is open seven days a week during the regular semester.

Figure 10. Photography of an instructor speaking to a group of makers in the Anderson Student Design Lab.

Figure 11. Students working at the bench table in the Anderson Student Design Lab.

For welding and more intensive woodworking, students will need to use the Student Shop, which is located in the Civil Engineering building. This lab is a half-open workspace with 3D scanners, 3D printers, materials testing load frame, and woodwork facilities. The Student Shop is also open seven days a week during the semester.

If students want to perform metalworks, they will need to use the Student Machine Shop in the Mechanical Engineering building. The machine shop is staffed by professional machinists with metalworking mills, lathes and grinders, milling machines, and waterjet cutter. Given the staffing hours, this lab is open only Monday through Friday during the regular semester.

5.1.2 Workflow and processes at Anderson Labs

Access to the Anderson Labs is granted if a student is enrolled in an engineering/CSE course or is a major or minor in any of the CSE programs. Non-CSE faculty and students can be granted access if they collaborate with CSE-related projects or received permission from Guengerich, the lab manager. For instance, participants of the Interdisciplinary Collaborative Workshop (ICW) were able to access the Anderson Labs (mainly the Student Design Lab) during the 2017 Great Plains Alliance for Computers and Writing pre-conference workshop on smart material technologies because one of the ICW collaborators, Dr. Julianna Abel, is a CSE/mechanical engineering faculty. From my interview with a CSE faculty, Ginny, I have learned that there have been a few non-CSE faculty members who had requested for access to the Anderson Labs and were granted access as long as they contribute to the CSE mission.

5.1.3 Maker experience at Anderson Labs

According to a mechanical engineering student who was a frequent user of the Anderson Labs, the makerspace was a response to the growing need for fabrication equipment for students. When asked of his evaluation of the makerspace, the student, whom I call Adam, stated:

> “The Anderson Labs were created in the last year of my undergraduate degree. I measure the success of the space in how it made projects that students were already doing so much better. In my introduction to mechanical engineering course, I built a robot on the floor in my dorm room. Now students in that course have dedicated workbenches and fabrication equipment. They see each other's progress, share advice, and occasionally receive ad hoc mentorship from older students.”

When asked to describe his overall observation of how he and his peers have utilized the space, Adam emphasized how students groups have made the Anderson Labs their home:

> “Student organizations immediately found a natural home in the new space. Their educational workshops have been able to accommodate a larger number of students because of access to tables and tools in a permanent and spacious location. The Anderson Labs have legitimized their freedom to create learning experiences, more powerful than those in the classroom because they are founded in camaraderie and peer mentorship.”

When I asked a student worker, Mickey, about his experience with working for Anderson Labs, he noted how the space is hard to find and therefore not getting many visitation from students:

> “The location of the space in the civil engineering building is particularly challenging. It is underground and difficult to find. For the first year of the space, a student employee was paid to do homework there without almost any users to assist.”

Mickey also observed that, from his 1-year experience working at the labs, there are more male than female students using the makerspace. He pointed out how that could be a problem for the growth of the makerspace:

> "I think the lab will present cultural barriers to new students who might use it. It is housed in the mechanical engineering building, a program with a historically low percentage of female students. Since mechanical engineering courses were early users of the space, it was not uncommon for me to walk into the lab and see 10 men using the space and not a single woman. I think it will be important to actively promote an environment where first-time users, regardless of their gender or familiarity with making, feel comfortable being in the space."

Adam, too, shared the same empathy for students who aren't granted automatic access to the labs. He thinks that it defeats the purpose of a makerspace as a cross-disciplinary learning commons if access is only granted to engineering students:

> "The fact that access to the Anderson Labs is limited to engineering students was incredibly frustrating to the student leaders who envisioned the space. Few classrooms allow students to work with peers studying a different major. Students recognize that the makerspace has potential to be a meeting place for different types of people whose aspirations are not bounded by disciplinary lines. I hope the next time I visit the Anderson Labs, I will see students studying art and design. The diversity of ideas and interests they would bring to the community is more than worth the meager cost to the College of Science and Engineering."

5.1.4 Key observations for Anderson Labs

Echoing the observations of the students I interviewed at Anderson Labs, the location of the makerspace is its biggest hindrance to many users on campus. It is a tucked-away space, isolated from where students typically meet and work (e.g., libraries, computer labs, student unions). As pointed out by Mickey, the lab in the civil engineering building is difficult to find. For someone who is not a frequent visitor to the building, the location of the lab might be a reason for the user to turn away from the makerspace.

Further, I also noticed that students perform more manufacturing work than design work when using the Anderson Labs. The way it is set up encourages students to cut, drill, and solder away their project rather than focusing too much on initial design. The lack of computers and spaces for sketching, drawing, and modeling makes it seem as though digital modeling and early sketching are not as important as building the prototype.

5.2 Invention Studio at Georgia Institute of Technology

The Invention Studio at Georgia Tech is a 4,500 square feet facility housed in the Manufacturing Related Disciplines Complex near the border of the campus, administered by the George W. Woodruff School of Engineering. The makerspace was founded in 2009, and has evolved over the years based on student and faculty use of the space. According to its history, the studio has always been supported by student volunteers. Today, the Invention Studio prides itself on being a fully student-run makerspace that has been modeled by emerging makerspaces around the country and the world.

I chose the Invention Studio because of its prestige and name known to the academic makerspace community. Although I did not know of anyone from the Invention Studio prior to my visit, I was introduced to the makerspace's faculty sponsor by Guengerich. As noted in the previous chapter, I have had a bit of a hiccup in arranging my visit at the Invention Studio to their wanting to review my IRB approval. Although it got smoothen out in the end, there were many exchanges between me, the Invention Studio faculty sponsor, and one of their research faculty members. Once I have received the green light to visit the makerspace, I was referred to a student volunteer who was a board member of the makerspace's official student organization.

5.2.1 Setup of Invention Studio

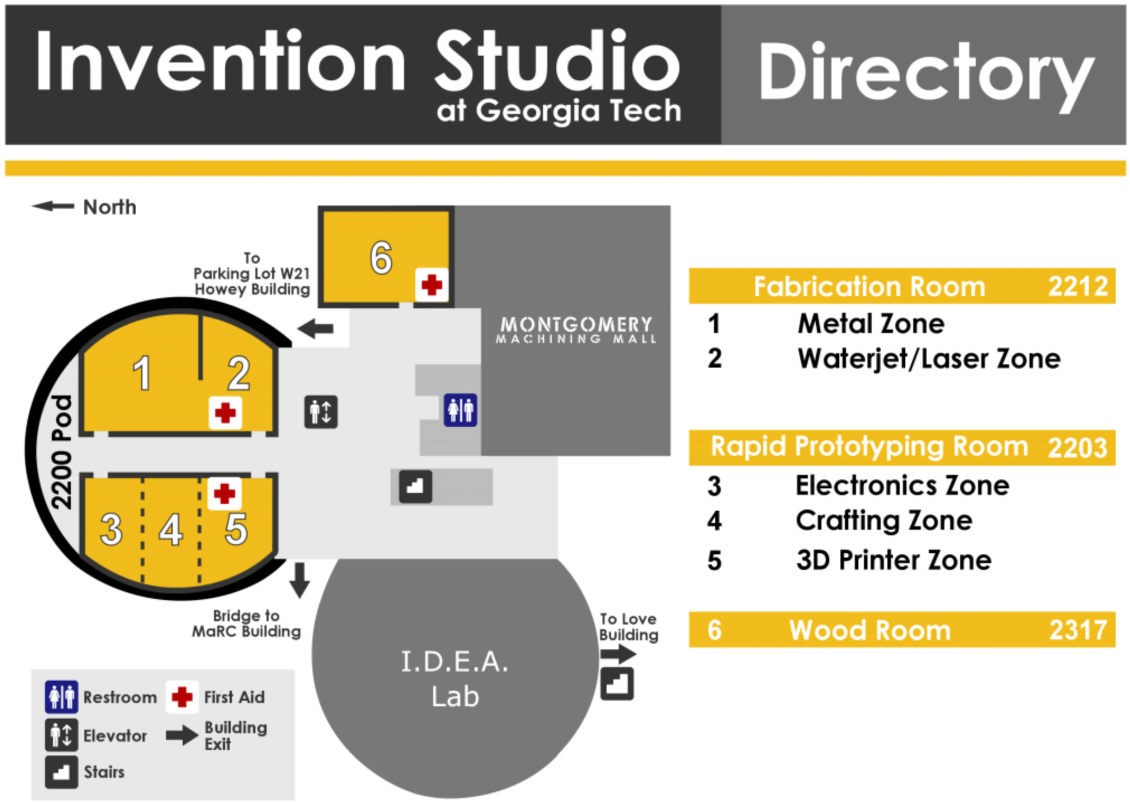

Figure 12. The Invention Studio floor plan (retrieved from the Invention Studio homepage).

The Invention Studio (Figure 12) was undergoing an upgrade at the time of this project. In summer 2017, the studio was under construction to occupy more space on the level where the studio resides. Offices were being removed to make room for the studio. At the time of my visit, the studio was made up of several rooms—wood room, metal room, 3D printers and electronics room, and waterjet and laser room. By the end of the remodel, the studio will combine some of these rooms to make the experience of making more comprehensive and convenient.

Because the entire facility is on the same floor, it adds a "home" feel to the studio. Any given point of my visit, 20-30 students can be seen roaming around the level and congregating in small groups around any open spaces they could find on the level. They were not afraid to leave their belongings (backpacks, computers, food) around, and go in and out of the several rooms through their open doors. I could hear music fading in and out between the rooms while in the hallways, as well as noises made by hand tools and printers.

5.2.2 Workflow and processes at Invention Studio

The Invention Studio is open to anyone at Georgia Tech. During the regular hours, anyone with a university ID can access the rooms at the studio without the need to obtain permission prior to their visit. There are monitors set up as check-in stations in each of the rooms (Figures 13 & 14) with a card reader. Anyone entering each room must first swipe their ID at the station, and do so again when they are done with the room for the day.

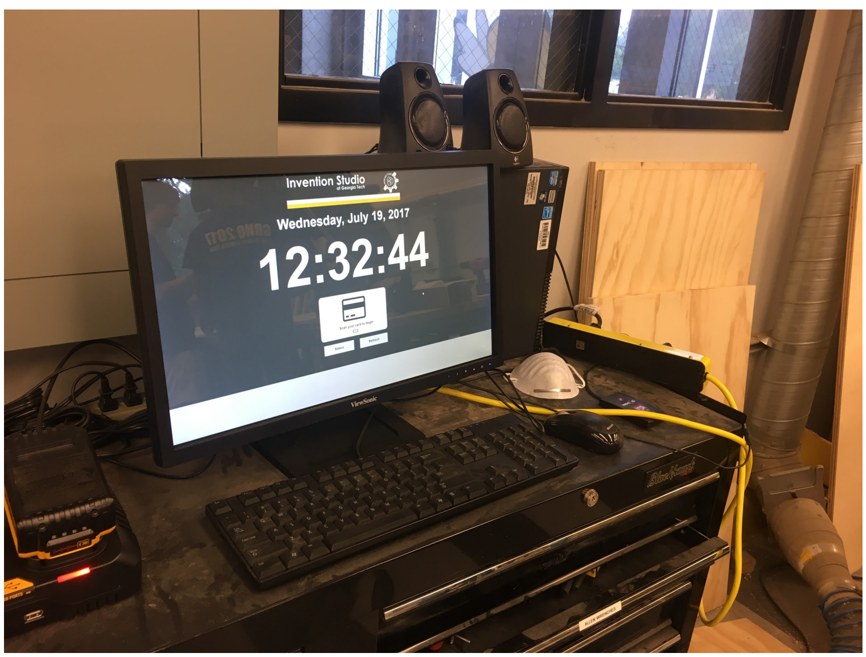

Figure 13. Photograph of a check-in station.

Figure 14. A check-in station in a room at the Invention Studio.

In every room there is at least one Prototype Instructor and a Prototype Master. Prototype Instructors are students who have undergone a specific certification program to be qualified as “tutors” to users of the Invention Studio. Prototype Instructors are identified with a yellow armband (see Figures 15 & 16). Prototype Masters are those who have been certified as a Prototype Instructor, and took additional training to become proficient in a specific power tool. They are identified with a red armband. A Prototype Master must always be present in the room in order for any users to use the tools in the room.

During my visit, I did not see any faculty or staff members present anywhere around the Invention Studio. All of the students and volunteers in the rooms appeared to be very conscious about the safety measures around tools. When I was entering the wood room for the first time, I was immediately stopped by a nearby student (who was working on his project) and asked to put on a pair of safety glasses before proceeding. I then noticed that everyone in the room was already wearing their safety glasses, even if they were just working on their computer there. Students were also diligent went using power tools. Some tools are marked as “training required” or users must ask for help from a Prototype Instructor (see Figure 17 and 18).

Figure 15. Prototype Instructors at Invention Studio wearing yellow armbands.

Figure 16. Close-up view of the armband for Prototype Instructor.

Figure 17. A marked power tool.

Figure 18. A Prototype Instructor helping users.

Since Prototype Instructors are not paid for their service, they receive after-hours privilege access to the Invention Studio. I was told that Prototype Instructors and Prototype Masters can use the facility 24 hours a day as long as they are not alone in the makerspace.

5.2.3 Maker experience at Invention Studio

According to a student manager of the Invention Studio, the goal of the makerspace is to support student projects, whether they are class-related or personal. Students were seen working in pairs or teams; I hardly found anyone sitting by themselves unless they were using a power tool. From my interview with a Prototype Instructor, Brian, I learned that volunteers strive to make the Invention Studio as welcoming a workspace as possible. They believe that no one would claim expertise in any project so everyone upholds an open mind and helps one another whenever necessary. Brian said,

> "Students tend to help one another with machines and ways of constructing something … especially those who are more experienced in the studio helping new users, like, 'Oh hey, there is a better way to do that.'"

Teresa, a student user and board member of the Invention Studio, mentioned how important of a role the makerspace played for her decision to attend the university:

> "When I found out that I got into Georgia Tech, I came down to visit and I visited the Invention Studio. It is one of the biggest reasons I chose to come to school here. During freshman year, I came to the space early on and started to get trained on all of the tools within the first 2 weeks. There was a checklist to become a PI [Prototype Instructor] and I wanted to get involved with the space as early as possible. And I really like going in and working on different projects as much as possible."

Brian also mentioned how the Invention Studio functions as a communal space for students:

> "It is just a really nice community of people even if you're not working on a specific project. We are really trying to promote a maker culture to get students to work on hands-on project. There are not a lot of classes at school that will give you the tools and resources to do that."

Further, students found the Invention Studio to be a home for their project even if they don't have a specific design in mind. Brian, a seasoned PI, talked about how the makerspace provides unlimited access to students who are experienced and novice alike:

> "There are a lot of machine shops on campus but they require a lot of qualifications before you could use the space. One of the biggest thing we want to do with the invention studio is to overcome the access barrier. We don't want to intimidate people. If you have never used something we still want to welcome you in. We want to get you building as quickly as possible."

To promote innovation, the Invention Studio provides grants for Prototype Instructors to create innovative projects. According to Brian,

> "We have an incentive program called The Maker grant for PIs. We would fun projects that includes learning a new skill or projects that are different or cool. That way we encourage people to work on their own projects."

Teresa recalled how she learned from other users of the Invention Studio who were not Prototype Instructors.

> "A lot of the time the users are helping other users because they have a lot of experience with the machines and that other PIs were busy at the time. They help one another when they see that somebody look like they have a question or they're unsure of how to use a certain machine. So there is a lot of collaboration going on even if the users are working on individual projects."

Brian added, that,

> "When we say that we are a fully run student facility we are truly a fully student-run facility. we have faculty members who advised ask on what equipment to buy but the ultimate decisions are made by the student board members. The Faculty members are really there to help us make wise decisions and also acquired sponsorships from industry."

5.2.4 Key observations for Invention Studio

During my visit, I noticed that students really own the makerspace at Invention Studio. There were no sight of faculty or staff members, and so the atmosphere was light and student-friendly. Through my interviews and conversations with users at the space, I sensed a strong student agency in the space; students declare a great deal of control of the makerspace and made it sound like it's their home. They have various examples of how they use the space for their own projects, as well as examples of how they meet up with friends and simply hang out at the Invention Studio not working on any projects.

The makerspace also seems to provide a consolidated experience for users. Since it is all located in the same building and on the same floor, there is a sense of unity and easy access to tools and materials. Students use every corner of the floor to their own advantage, including a mini meal area where a public microwave sits (Figure 19). During my visit, I also saw some student teams working on projects for a competition (Figure 20). They spread their tools and stuff across a bench in the common hub area and did not feel intimidated by passers-by. This was a very encouraging scene as I saw those students working hard on their projects and the space affords that kind of spirit.

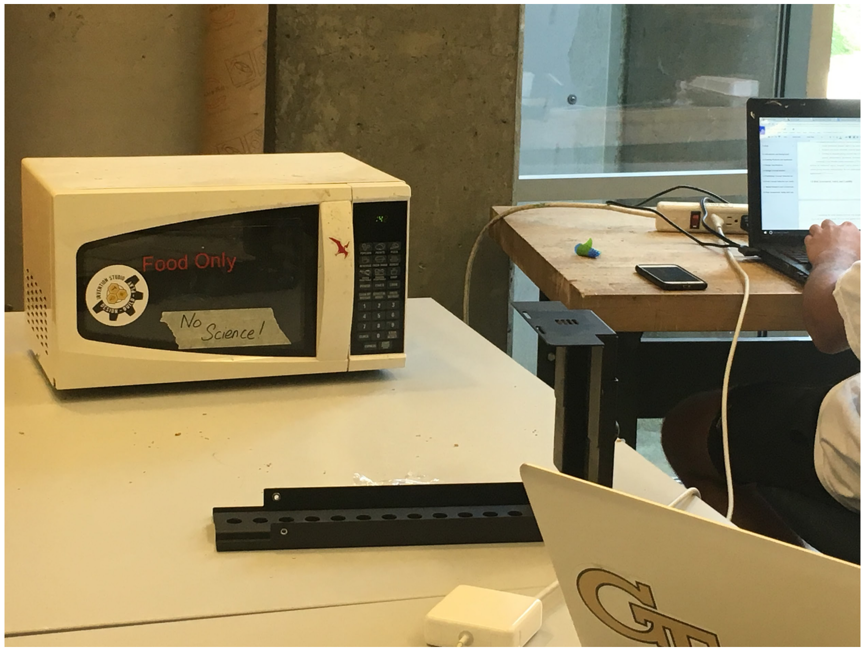

Figure 19. Microwave in the public hub.

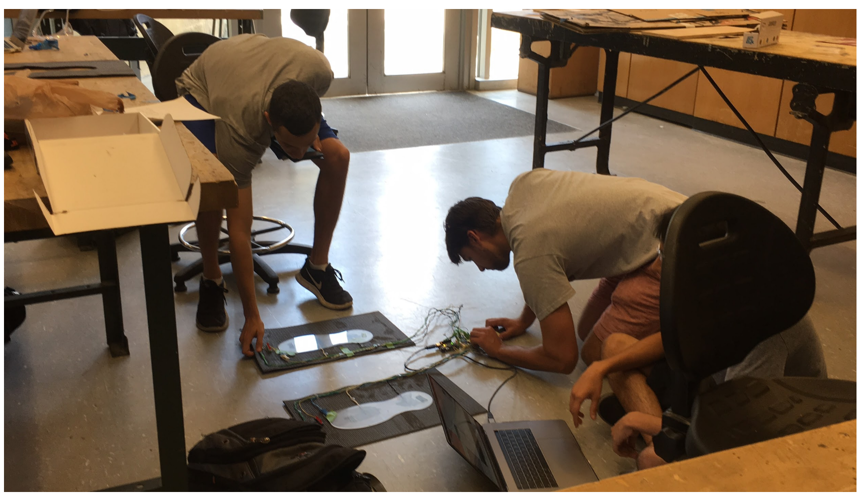

Figure 20. A student team working on the floor.

5.3 Sears Think[box] at Case Western Reserve University

I was introduced to the nationally known makerspace at Case Western Reserve University, the Larry Sears and Sally Zlotnick Sears Think[box], by Guengerich at UMN. At a time when I was still choosing my sites of observation from the available academic makerspaces, Guengerich recommended Think[box] as a great model makerspace to look at, due to its renowned staff members and growing influence on academic makerspaces around the country. In fact, Think[box] was the host for the second International Symposium on Academic Makerspaces in 2017, taking the baton from the previous symposium leader, the MIT.

Think[box] is a 7-storey, 50,000 square feet facility—a standalone building dedicated entirely to being a full-scale makerspace to the Case Western campus. Think[box] began in December 2012 in a smaller, 5,000 sq.ft. space where protocols, training, and processes were tested that would be appropriate for an open-access mission. In October 2015, it moved into the first phase (Floors 1 to 4) of its permanent home, with renovations continuing and phase two completion of additional floors in Fall 2016.

5.3.1 Setup of Think[box]

Think[box] is open to all Case Western students, faculty, staff, and even the community at large. The makerspace brands itself as a center for entrepreneurship and innovation. The design of the building (Figure 21) mirrors a 7-step process to a start-up business:

- Floor 1 - Community: a welcome center for anyone; gathering space
- Floor 2 - Collaboration: a meeting space to brainstorm ideas; collaborative ideation
- Floor 3 - Prototyping: the initial makerspace; digital prototyping and development
- Floor 4 - Fabrication: the next makerspace; non-digital construction and manufacturing
- Floor 5 - Project Space: a large space for teams to test their physical prototypes
- Floor 6 - Entrepreneurship: temporary cells for teams to assemble initial business endeavors
- Floor 7 - Incubator: temporary office spaces for startups

Figure 21. A floor directory next to the elevator in Think[box] showing the purpose of each floor.

During my visit, I was allowed to Floors 1, 3, 4, and 5. The figures below show the layout of those floors (which I photographed while touring on these floors).

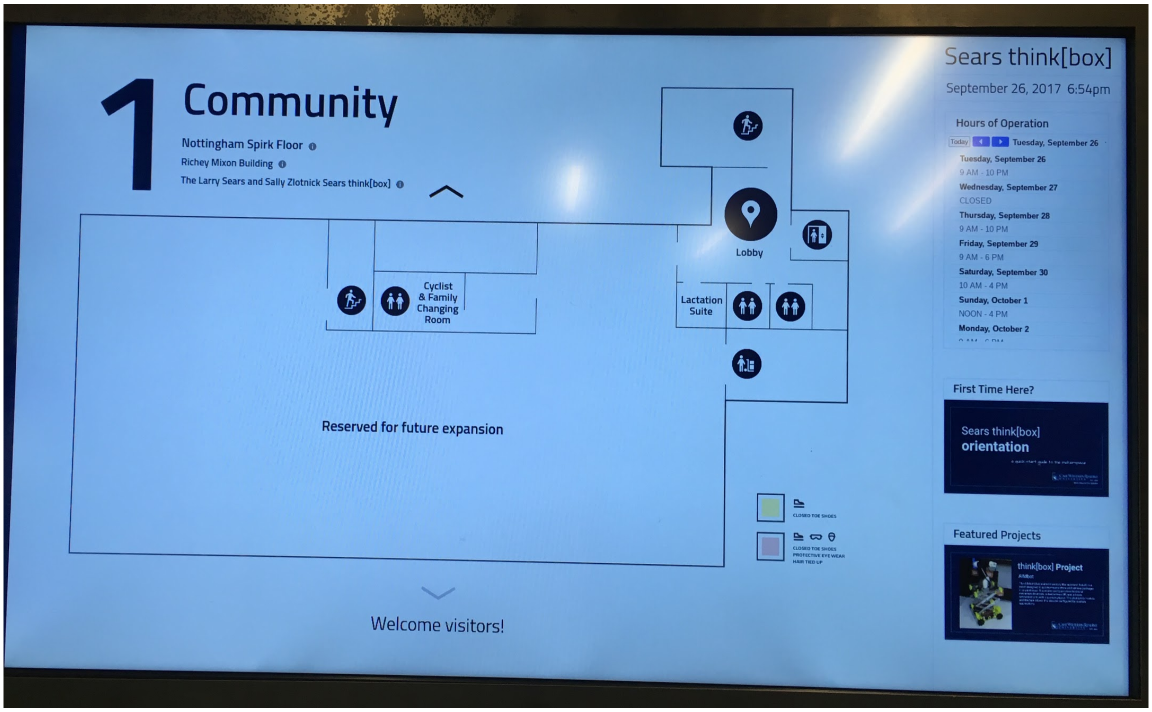

Figure 22. Layout of first floor (community space).

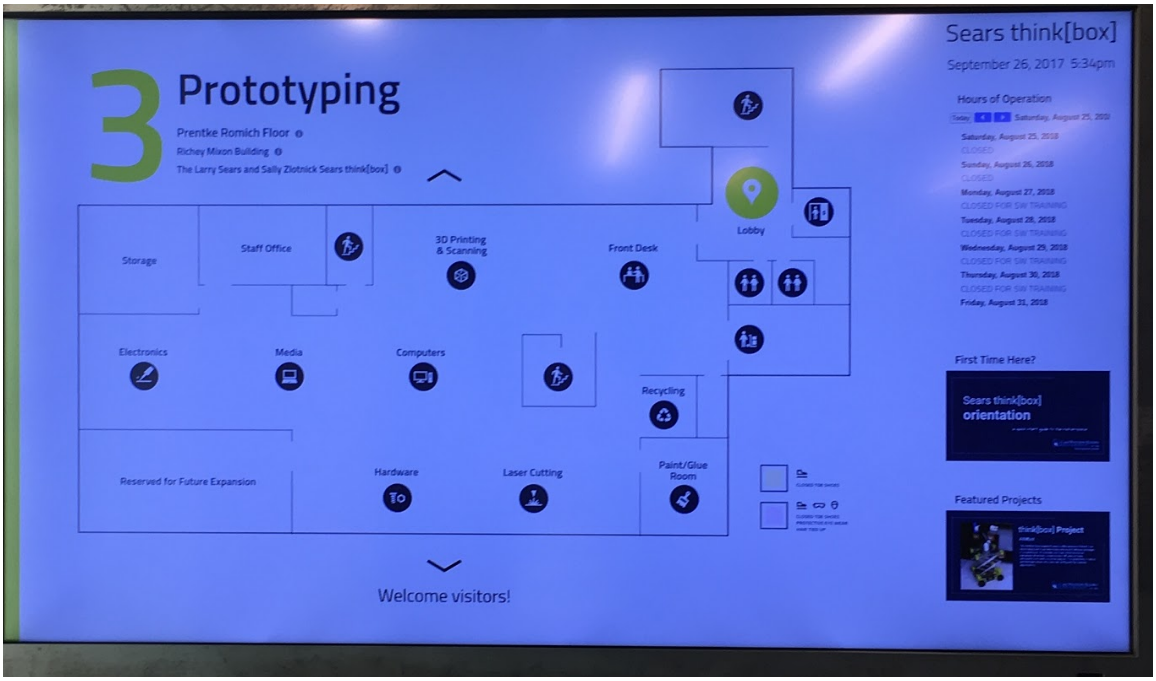

Figure 23. Layout of third floor (prototyping space).

Figure 24. Layout of fourth floor (fabrication space).

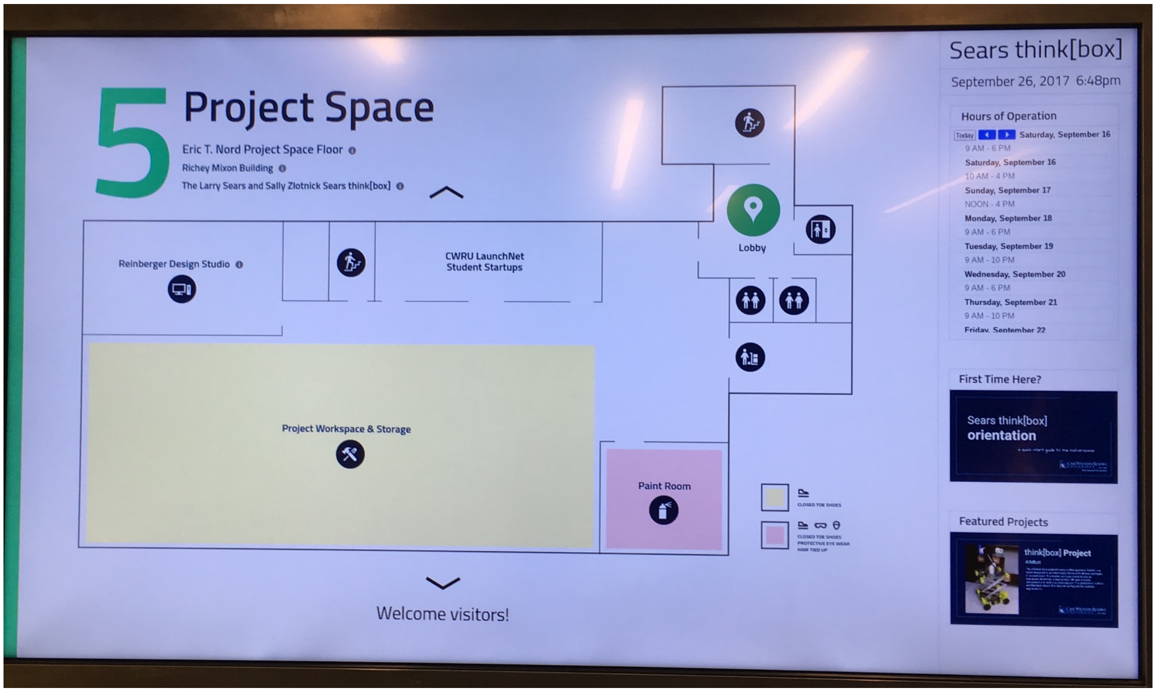

Figure 25. Layout of fifth floor (project space).

Students typically occupy Floors 2 to 5, using the fabrication materials and tools to build their own projects. The layout of the two main “making” spaces, Floors 3 and 4, is very defined and organized (Figures 26, 27, 28, and 29). The space is clearly marked with dedicated areas for reception, computer-assisted design or work, hand tools, power tools, hardware and materials, material disposals, electronics, higher-risk activities such as laser or waterjet cutting, and a “dirty room” where prototypes get sanded or spray painted (safety glasses required in this area).

Figure 26. The 3D printer area in Think[box].

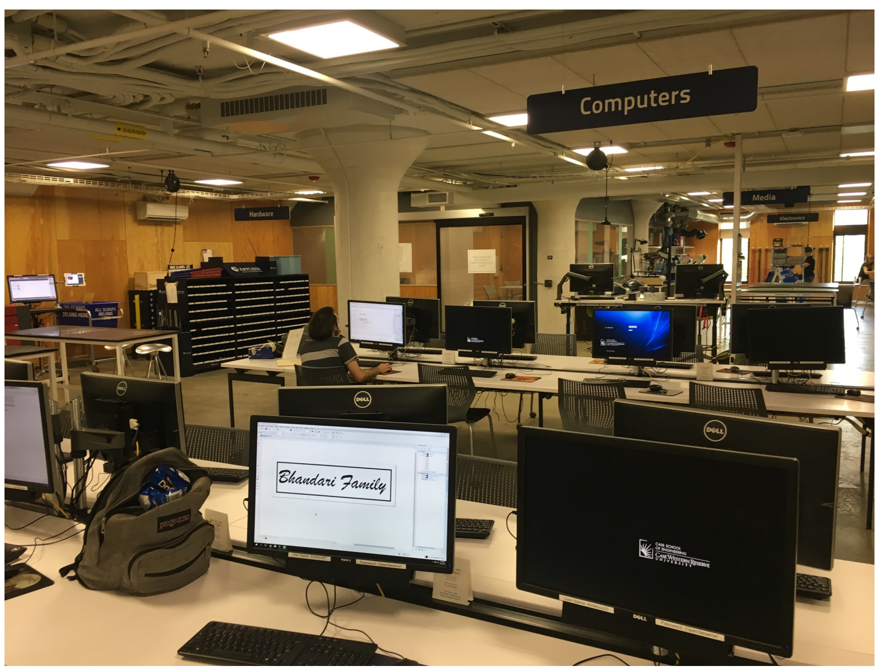

Figure 27. The computers/desktop design area in Think[box].

Figure 28. The electronics area in Think[box].

Figure 29. The hardware storage area in Think[box].

According to my tour guide, Think[box] is open about 63 hours each week in the regular semester, and about 20% of the traffic is from the public (non-Case Western community).

5.3.2 Workflow and processes at Think[box]

Think[box] is an open-access makerspace; according to its website, it also serves neighboring higher education institutions, nonprofit organizations, as well as area industry. Everyone walking into Floor 3, the main reception for the makerspace, has to sign in using a tablet at the reception desk. Users are expected to familiarize themselves with safety measures and acquire knowledge of the power tools they plan to use on Floor 4. Unlike the Invention Studio, Think[box] does not have peer instructors who monitor the makerspace. It does have student workers who are paid for cleaning and helping users in the makerspace with various tools, be it using a computer design software, locating materials, using a hand tool or power tool, or discussing design ideas.

The makerspace receives material donations from area industry, such as plywood, filaments for 3D printers, and other raw materials. Therefore, students are not required to pay for using these supplies in the makerspace. On Floors 3 and 4, there are recycling and waste disposal spaces that are clearly marked to encourage students to put away their unused materials. Students, however, need to pay for acrylic. They and any Case Western alumni get a discounted rate compared to public users.

The overall atmosphere is light and seemed conducive for work. There was no background music. The student workers in the space are identified with their green apron and nametag. They walk around the space and are seen constantly clearing up clutter and putting tools back into their storage areas. During my visit, there were about 11 students in the makerspace on Floor 3. I observed one female student worker helping three students at the computers area at the same time. Another male worker was cleaning a workbench, before he turned his attention to a male student who was trying to laser cut a wooden gift for his friends. The student worker offered to help the student, who turned out to be his classmate, to remove the stains on the wood after being cut up by laser, and he reminded his friend to wear goggles and gloves before entering the dirty room.

To access Floor 4, students must complete a few basic training online or one on one with staff. They get ability badge after completion; they must wear them when entering Floor 4. Students are also required to wear closed-toe shoes when visiting Floors 4. In case they forget, the floor provides safety crocs.

According to a student worker, there are workshops, events, informal courses—anything dealing with an innovation ecosystem tends to occur in the space. When I toured the first and second floor, I was shown many collaboration spaces that resemble an active learning classroom—with pods and monitors and whiteboards where users can do focused brainstorming and discussions. There are also free coffee and tea. Since the building is a little bit away from the main student center on campus, there is even a pizza vending machine on the first floor.

To ensure student safety after business hours, a buddy system is enforced after hours. Users must be in pairs in order to remain in the building, and no one is allowed in there after midnight.

5.3.3 Maker experience at Think[box]

Users of Think[box] seem to appreciate the clean layout of the makerspace. When asked for her opinion of the makerspace, student user Nicola mentioned more than just the design of the building—she also appreciated how its configuration encourages conversations among users:

> "The building is very well designed. It is beautiful. It is very well laid out. They have things that are centered… like, you can use the laser cutter and still talk to somebody about what they are working on. It's really important that way. The fact that you can see a 3D printer is printing and you can have a conversation with whoever is printing regarding their construction and what their end result is. It's really great."

In addition to the layout, Nicola also highlighted how the staff members of Think[box] have made her feel welcomed at the space. She noted the friendliness in the staff, which encouraged her to visit Think[box] often:

> "Think[box] has great energy, and great people. It's a great place to test an idea, to explore an idea. You have the resources there, you have the materials there. You also have the knowledge there. The staff members are super great. They are very knowledgeable, very friendly. I don't specifically see a lot of them a lot of the time. But when I re-introduce myself to them, they remember what I am working on. I try to get up there as much as possible."

Nicola also shared how working in Think[box] gave her the experience to work side-by-side industry practitioners:

> "They have working professionals there who are willing to help you with your project. They seem fun and are interested and invested in the project you are working on. I have met architects and engineers there."

Another student user that I interviewed, Ryan, was a junior art student at the Cleveland Institute of Arts (CIA). I have learned through Ryan that the CIA has a unique collaborative relationship with Case Western Reserve University, and that students from both institutions often collaborate, including working together in Think[box]. Ryan was grateful for resources that he received as a CIA student through the makerspace:

> "I have a one-year grant through the Think[box] so they supply me funding to support my own independent project. I will go there to 3D print, I will go there to laser cut. I will go there to just do general manufacturing. Sometimes I will just go up there to talk with other people and to see what they are working on. It's an interesting environment. It's just really fun to be up there."

When asked of his opinion on the kind of collaboration fostered through the Case Western-CIA collaborative initiative, Ryan noted that such effort is plausible because it brings artists and engineers together:

> "Think[box] is very crucial for my academic development. At the Cleveland Institute of Arts, sometimes it is very dense there with artists, and you are not exposed to engineers, to makers. It is nice to get out of there. This is one of the

reasons I chose to study at the CIA—it's because of its relations to Case Western and the Think[box]. There are about 500 students at the CIA, and I know there are a couple of foundation classes that push students to the Think[box]. Maybe 10% of CIA students make it over there before they graduate."

Ryan mentioned that Case Western and CIA students have sparkled really interesting collaborative projects, some of which he noted below,

> "A lot of CIA students and Case students collaborate through the Design for America project. There are teams that have won the competition and started their own company. It is crucial for this kind of collaboration, because, no offense, but sometimes engineers don't know how to design [laugh]. The same goes for the arts. Sometimes artists don't know how to effectively create something. Last year, CIA had a fashion show based on objects that would be used in the industry for interior architecture. We laser cut something called deco leather and we made this beautiful dress out of it. So whether it's for personal projects or class assignments, there is definitely a reason to use the Think[box]."

As with Nicola, Ryan is grateful for the resources made available through Think[box] and that students did not need to pay for most materials. He thinks requesting for more resources like adding a few more laser cutters would qualify as being greedy:

> "If I were to get greedy, I would say add four more laser cutters so I don't have to wait. But honestly they have it laid out so well. You come in, you have a question you can ask a technician or somebody who has done it before. And then you just do it and you are on your way—you have already started your fabrication and you are ready to complete your project. I don't really have any complaints… other than you have to wait 30 minutes to use a laser cutter."

5.3.4 Key observations at Think[box]

From my observation as well as interviews with users and managers of Think[box], I also noticed a strong sense of community. The Think[box] website points out that the makerspace aims to serve not just students at Case Western, but also the greater Cleveland community—business and non-business organizations alike. As it is evident through student user Ryan's experience, he benefited from an academic collaboration between CIA and Case Western. Nicola, too, pointed out that she was able to meet working engineers and architects in the makerspace. Think[box] really presents itself as a common space for communities beyond the university.

The overall atmosphere of Think[box] screams "entrepreneurship"—the way it is set up, run, and promoted seems to emphasize how projects can get ideated, designed, fabricated, and shipped as profitable products in a streamlined design process. This process mirrors the 7-step start-up route, which is also how the makerspace is built (seven storeys). The additional incubator and project spaces make Think[box] different from the other two makerspaces I observed.

In the next section, I present a more detailed comparative discussion of similarity and differences among the three academic makerspaces.

5.4 Comparative findings

The biggest similarity among the three makerspaces I have observed is that they serve mainly engineering students and faculty. In my site selection process, I have worked to ensure that all of the makerspaces I study would be open-access so to avoid disciplinary bias in how they are set up and operated. However, even though the news about the opening of the Anderson Labs makerspace appealed to its accessibility and service to the university as a whole, I later found out that it's only primarily serving the CSE and engineering faculty. This seems to be the case for the Invention Studio and Think[box] as well, although these two makerspaces do not limit access to just students or faculty from a particular college or department (it makes sense because all of Georgia

Tech or Case Western Reserve University is like a giant science and engineering department).

Since all three of the makerspaces are relatively big and known nationally as models for emerging makerspaces, they are well-equipped in terms of the tools and materials made available to users in the makerspace. They all have similar fabrication and manufacturing tools, workbenches, and collaborative spaces where users can meet and discuss ideas. Both the availability of the tools and the layout of the space are what make makerspaces unique active learning spaces. The bias to action driven learning forces users to put their ideas into tangible, testable forms early rather than getting stuck in the discussion of their ideas. These spaces are also designed with a design thinking philosophy, where failures are celebrated as part of the design process not to be ashamed of but instead used as guides for the next, iterative design.

The design of the makerspaces also fosters horizontal, or peer-to-peer learning. As most of my student interviewees have pointed out, they find values in all three makerspaces for enabling them to learn from other users in the space while working on their own projects. They offer the same guidance or advice to other users whenever they are asked for help. This kind of learning seems desirable as students are less intimidated by their peers compared to their instructors. They also learn to be a mentor to others when they become proficient in a tool or a making process, helping them acquire skills to teach others.

Finally, I also noticed that all three makerspaces have active student involvement in its core operation. In each of these makerspaces, there are student groups or organizations that either help run the facility or use it to perform learning activities that benefit the university at large. For instance at UMN, student clubs like Tesla Works and Design U lead an annual university-wide makeathon that takes place in the Anderson Labs. At Georgia Tech, there is an official student club for the Invention Studio that organizes a similar design competition. Georgia Tech students also serve as board members and train to become Prototype Instructors or Prototype Masters who volunteer in the makerspace. I was informed by student users at the Invention Studio that all tools and technology purchases are requested by students and the affiliated faculty only signs off on the purchase requests. Lastly at Think[box], students are paid as workers and technicians in the makerspace. From my site visit, I did not see any non-student technicians at Think[box]. All three of the sites really come across as student-friendly, even more so than other traditional student learning facilities like the university libraries and writing centers. The kind of student involvement in makerspaces can be a model for these traditional learning spaces.

In terms of differences, I noticed that the three makerspaces are of different sizes and occupying their respective campuses in different ways. With more than 50,000 square feet, Think[box] is the largest among the three sites I visited, followed by the UMN Anderson Labs at about 10,000 square feet, and lastly the Invention Studio at only 4,500 square feet. While the size of the makerspace does not represent its prominence or success, they require different operation and run on different budget. Based on my study, the UMN Anderson Labs relied on a generous donation and are administered by CSE, one of the larger college units in the university system. Similarly, the Invention Studio is supported by a larger academic unit, the George W. Woodruff School of Mechanical Engineering. However, Think[box] is an independent unit. In its "Playbook[29]," the makerspace describes the importance of engaging faculty, alumni, and key university players, as well as external partners to create an "ecosystem" that would support a standalone student-serving facility.

Another difference in these three makerspaces is what I call its persona. If I see each of these makerspaces as individuals, I felt as though I have made three different friends, each with unique personality and character. The first friend, the Anderson Labs, is focused on manufacturing. I would refer to this friend as "the shop." Students are seen working with wood and metals more than computers and 3D printers. My second friend, the Invention Studio, comes across as more developmental. I call this friend "the design space." Students are seen tinkering and prototyping using both digital fabrication as well as manufacturing tools. However, there are less welding and more 3D printing and electronic circuitry that's going on compared to my "shop" friend. Lastly, my third friend, the Think[box], is who I would refer to as "the entrepreneurial center." It is very

[29] See http://thinkbox.case.edu/sites/engineering.case.edu.thinkbox/files/images/thinkbox-playbook-for-web.pdf

apparent in its presentation and promotion that this third friend focuses on turning prototypes into start-up products. The entrepreneurship and incubator floors in the Think[box] building are physical manifestation of this ideal.

The last main difference among the three makerspaces is their community engagement. Each of them has varying level of engaging external entities such as business organizations and sponsors. The Invention Studio makes it obvious that most student projects are sponsored by businesses around the area. Brand names and company logos can be found on banners and posters that are hanging around the Invention Studio. The UMN Anderson Labs, on the contrary, have almost no showing of corporate investment in its makerspace. Community engagement for Think[box] means not only bringing corporate sponsors to student projects, but also inviting them to use the makerspace for their own projects. The entrepreneurship and incubator floors in the Think[box] building is where businesses could rent temporary workspaces to create their own start-up initiatives. Table 3 shows a summary of my comparative findings.

Table 3.

Summary of similarities and differences between Anderson Labs, Invention Studio, and Think[box].

	Anderson Labs	**Invention Studio**	**Think[box]**
Main users	Engineering students and faculty.		
Facility	Well-equipped with tools and materials to support projects at various scale.		
Learning style	Horizontal, peer-to-peer learning. Decentralized power dynamic (students take charge of their own learning).		
Student involvement	Active participation by student groups/organizations and volunteers.		
Size	10,000 sq ft	4,500 sq ft	50,000 sq ft
Administration	Funded through donation; administered by College of Science and Engineering.	Funded and managed by George W. Woodruff School of Mechanical Engineering.	Fundraised and managed by staff members; receives support from community partners.
Persona	"The shop"	"The design space"	"The entrepreneurial center"
Community engagement	No corporate investment.	Student projects are sponsored by businesses.	Student projects are sponsored by businesses; corporate sponsors are welcomed to use project spaces.

5.5 Students' Use of Makerspaces

During my visits, I have had the opportunity to speak with students about their projects. Since my research questions include the need to understand how students use these makerspaces, I have focused my thematic coding of student responses to three specific categories: 1) purposes, 2) methods, and 3) outcomes. Here I share the results from these three categories.

For comparative purposes, I looked for responses that describe the students' goals in using their respective makerspaces. I have found that students utilized the tools in the makerspaces to do both personal and class projects. Four out of the six students I interviewed said they were working on personal projects. These projects included gifts for family or friends and parts for an existing design the student is working on. They all expressed appreciation to the makerspaces for letting them use materials and tools in the facility without charging them a hefty fee. Most of these students were also working on class-related projects in the makerspaces. At the Invention Studio, I saw multiple student groups that were working on similar projects (baby strollers). It was an indication that it was a class project (Figures 30 and 31).

Figure 30. Two students working on stroller in the Invention Studio.

Figure 31. Another student working next to strollers by the Invention Studio.

I have also asked students how they are working when in the makerspaces. Their responses indicate mostly collaborative approaches to working on projects. Six of the students I interviewed revealed that they relied on other users in the makerspace when carrying out their projects. Although some of their projects were independent, these students revealed that they have asked other students for help at some point during their work in the makerspace. Whether they were needing help with a specific technology or simply asking for an outsider's perspective, they noted how those external points of view where helpful for the development of their work. A student has especially noted that by exposing her work to other users to the makerspace she was "letting other users critique her work" and thus gaining perspectives she wouldn't usually receive in a classroom setting.

In terms of the outcomes, or what students get out of working in their respective makerspaces, I have learned that students acquired new skills, team work experience, and a special learning-to-learn ordeal given their engagement with a makerspace. Most of the students I interviewed noted how working in their makerspace has taught them to be learner who is motivated to succeed in their respective projects as well as helping others who are working in the space. The students have expressed a sense of pride when they are able to assist others in the makerspace. Ryan, for instance, noted that his involvement at the Think[box] has taught him to be sensitive to other users of the makerspace and be helpful whenever possible. At the Invention Studio, Nicola noticed that she learned from other student makers in the space because she doesn't think that she knows everything. She mentioned that she learns from others' mistakes and was able to apply the experience into her own project. Such learning environment is unprecedented by other kinds of learning facilities in higher education.

Reflecting back on my whole experience of visiting with these students, makerspace managers, and observing the sites, I acknowledge the limitation to these visitations in terms of my time spent at each makerspace. It would have been a greater data collection experience if I spent more time observing at the respective sites. Due to funding limits, however, I was only able to spend two days at each makerspace. As I interviewed the student makers in these spaces, I have also learned about some very interesting projects these students were undertaking. These projects are worth a longitudinal study. Future iterations of this research may consider following student makers and their journeys of making in order to study their creative processes. Nevertheless, this project, especially this part of the study, has allowed me to gain firsthand knowledge and experience in three different makerspace communities. These knowledge and experience prove to be critical to my design of a maker-based TPC course, and I will discuss my deployment of this course and its results in the following chapter.

5.6 Chapter summary

In this chapter, I reported the major findings from my visits to three academic makerspaces—Anderson Labs at the University of Minnesota, Invention Studio at Georgia Institute of Technology, and Think[box] at Case Western Reserve University. I have introduced all three makerspaces in detail, in terms of their respective setup, operation, workflow and processes, and maker experiences. I have then combined the discussion and provided a comparative review of similarity and differences among the three makerspaces. I close with a brief review of students' use of these makerspaces. All of these findings inform my design of a maker-based TPC course, and I discuss its deployment and findings in the next chapter.

CHAPTER 6

A "Maker" Approach to Teaching and Learning TPC: Descriptions and Findings from a Pedagogical Case Study

The exigence of this dissertation is underscored by the need for TPC to reinvigorate its pedagogy so students can be more effective multimodal problem solvers in the 21st century workplace. To do so, I have proposed an attempt to redesign a TPC course by leveraging the benefits of maker practices popularized by the recent Maker Movement. Specifically, it aims to address the third supporting research question of this dissertation: How might we teach TPC through the making and makerspaces? This chapter shares the development of a maker-based TPC course and the results from a pedagogical case study of this course deployment. Included in the following pages are the descriptions of this course design, students' engagement in the course, their projects, and their reactions to the course. I also detail my own experience from the instructor's point of view.

6.1 Designing a TPC course with a maker emphasis

In the previous chapter, I have discussed how makerspaces allow students to learn to solve problems by tinkering with new tools even though they might not have prior experience with the tools or specific manufacturing processes. The makers in Anderson Labs, Invention Studio, and Think[box] were working on projects of varying scales—ranging from engraving personal greeting cards to designing 3D cameras. The availability of digital fabrication tools like 3D printers and CNC milling machines allow them to perform lower-stakes experimentation. Through trials and errors, students learn by adjusting their problem-solving process—changing their measures, adapting from previous conditions, modifying assessment criteria, etc. These notions of tinkering and adaptation are an important consideration in the design of my maker-based TPC course. Such a course should afford students with access to tools and technologies they need to experiment and prototype, moving ideas from conceptualization to materialization.

To mobilize this prototyping approach to learning, I have integrated design thinking as a structured methodology for the maker-based TPC course. From my makerspace observations, I have learned that students follow the design thinking methodology closely when working in a makerspace. Design thinking manifests like a habit of mind for these students, and it is ingrained in their language. In my observations, I noticed that students often spoke of their "prototype" design, of an "iterative" process to "manufacturing" solutions, and of "human-centeredness" in their solutions.

When designing the maker-based TPC course, I have also considered ways to incorporate collaborative learning. In my makerspace observations, all student interviewees referenced their social experience in their respective makerspaces, and how much they felt to have learned from other users in the space. Similarly, most of them talked about helping other users in the makerspace as well. This realization is key for learning in an informal setting, and through my observation, it can also be an important stepping stone for learning technical communication since the technologies in TPC pedagogy are always evolving. A maker-based TPC course should let students solve problems together.

In short, I have utilized the lessons I learned from observing the three makerspaces in the previous chapter, summarized in terms of tinkering, design thinking, and collaborative learning as the guiding principles to creating a maker-based course for TPC. What makes this redesigned course truly "maker"-based is not just its subscription to maker culture ideals, but the whole structure of the course that motivates students to tinker with new technologies, cultivate design thinking, and learn collaboratively. I have identified these key elements from my direct observation and exchanges with students who were working on projects in the three makerspaces I visited. Thus, this redesign would not have been possible without my firsthand experience with makerspaces through Part 1 of this study. In the next section, I provide an overview to the course in which I have redesigned and the details to its content and assignment sequence.

6.1.1 WRIT 3562W course descriptions and learning objectives

I have chosen WRIT 3562W Technical and Professional Writing as the course to experiment a maker-based redesign because it is considered an introductory course that is not restricted to Technical Writing and Communication students. Some scholars in our field call this kind of course a service course as it serves as an upper-level writing course for students across majors, allowing TPC instructors to reach those who outside of our discipline. Having taught WRIT 3562W twice before this course redesign, I have experienced the flexibility this course offers in terms of content and the potential for this course to influence TPC and non-TPC students. Thus, it is an appropriate course for this redesign effort.

According to the official teaching resources—the Advanced Writing Instructor's Guide—found on the Writing Studies Department's intranet, the official university catalog course description for WRIT 3562W is as followed:

> Technical and professional writing communicates complex information to solve problems or complete tasks. It requires not only knowledge of workplace genres, but also the skill of composing such genres. This course allows students to practice rhetorically analyzing writing situations and composing workplace genres: memos, proposals, instructions, research reports, and presentations.

WRIT 3562W is a 4-credit course with prerequisites or junior and senior status requirement for registration. This course is offered every semester including the summer. It also has a double writing-intensive[30] designation, one of its kind within the university. The Writing Studies department has an expanded description for WRIT 3562W:

> Technical and professional writing is writing that communicates complex information to readers or users to solve problems or complete tasks. Any study of technical and professional writing will require not only knowledge of workplace genres, but also the practice of the skills needed to compose such genres. This

[30] See requirements for writing-intensive courses here: https://onestop.umn.edu/writing-requirement

writing-intensive course will introduce students to and allow them to practice the following:

- Composing workplace genres such as memos, letters, proposals, instructions, and reports
- Explaining detailed and complex technical information to diverse audiences
- Rhetorically analyzing writing situations, multiple purposes, and potential audiences
- Designing visual and verbal information, and working with text arrangement and document design
- Understanding and practicing features of "readable" written communication such as grammar and style
- Conducting research and clearly conveying results of research in written and oral formats
- Considering ethical implications and the ways knowledge, power, or human activity impact writing

Students can expect to fulfill three of the seven official universitywide undergraduate student learning outcomes. As the Advance Writing Instructor's Guide states

> Students who successfully complete WRIT 3562W will have met these three Student Learning Outcomes[31]:
>
> 1. Can locate and critically evaluate information. Students will obtain this outcome by doing the following activities:
>
>   - Conducting research using various information- gathering strategies: library research, surveys, interviews, internet searches, etc.
>   - Assessing the credibility of sources and critically evaluating the quality and appropriateness of the information to produce the most reliable evidence

[31] See all universitywide student learning outcomes and their descriptions here: http://academic.umn.edu/provost/teaching/cesl_loutcomes.html

- Assessing information that doesn't support the hypothesis
- Relying on logical and rhetorically coherent arguments
- Effectively managing a lengthy project

2. Can communicate effectively. Students will obtain this outcome by doing the following activities:

- Writing workplace genres, including memos, letters, proposals, definitions, instructions, and reports
- Analyzing audience and adjusting communication for varying audiences to advance the writer's/speaker's purpose
- Technically describing a complex product or process to a general, public audience
- Composing a set of instructions to teach an audience how to complete a procedure
- Constructively working with other students on a collaborative assignment
- Preparing and delivering an oral presentation using PowerPoint or Prezi
- Using a variety of writing technologies such as word processors, presentation software, blogs, wikis, discussion forums, and Google Docs to design usable documents
- Appropriately applying features and formatting conventions of workplace writing
- Practicing writing that is grammatically correct and stylistically appropriate
- Creating graphics such as charts and graphs that ethically display information
- Understanding ethical issues and its implications for technical and professional writing (misinformation, confidentiality of information, etc.)
- Revising and editing one's own writing and that of classmates

3. Can identify, define, and solve problems. Students will obtain this outcome by doing the following activities:

- Writing a research-based report that addresses a specific problem or research question
- Conducting usability testing to ensure that the project meets the needs of the reader and the goals of the project
- Creating a proposal to convince an employer to move forward with a project

Minimum assignment requirements for WRIT 3562W includes the following items included in the Advanced Writing Instructor's Guide:

Instructors should address a minimum of three emphasis areas or assignments:

1. Technical Description or Technical Definition (explanation of technical content). A technical description addresses specifications of a product and often includes a visual. A technical definition is more verbal in nature and explains a technical or mechanical term. An assignment could ask students either to produce a technical description or definition OR to analyze an existing technical description or technical definition. Either way, this assignment would be an excellent first assignment for the course, as it would introduce nuances of technical language and communication of technical information to a range of audiences. However this assignment is designed, it should be an individual assignment to give students experience explaining and/or analyzing the explanation of technical information.
2. Instructions + usability (documentation, visuals, document design). Instructions (and documentation of any sort) are one of the most common form of technical writing. Technical writers often document processes, products, specifications, instructions, and more. Many forms of documentation include a combination of visual and verbal information, as well as clear steps, parallel voice, and consistent use of terminology. Most

instructors feel that a collaborative approach to this assignment yields more interesting and higher quality instructions. The instructors integrate conventions such as numbered steps, command style and parallel writing, labels and visuals, and succinct explanations. Instructions could be done in a variety of modes: text, visual, video, audio. Usability is a necessary component of instructions and can be effectively integrated in the assignment by having student groups test each other's instructions.

3. IMRaD Report Research Project (problem-solving, empirical research, audience analysis). The research report must be an individual report and include these components: (1) problem-solving purpose (2) some form of empirical research (interview, polls, survey, focus group, experiments) (3) clear address of audience--a specific individual or organization with an address. The research report is a large assignment that includes several subgenres:
    1. Proposal for project
    2. Data Display
    3. Progress report
    4. Correspondence (e.g. letter of transmittal, cover letter)
    5. IMRaD[32] report
    6. Presentation

My design of a maker version of WRIT 3562W is based on the above requirements (course objectives, student learning outcomes, and minimum requirements). In addition, I have included the aforementioned key aspects of maker-based learning—tinkering, collaborative learning, design thinking—creating a course that aims to deliver the major genre knowledge of technical communication while exercising the maker practices. The course description on my syllabus[33] reads:

> This 4-credit writing-intensive (WI) course is designed around a semester-long design challenge to help students acquire technical communication knowledge

[32] Introduction, methods, results, and discussion
[33] See Appendix A for full syllabus.

and competency in today's context. Students should expect to engage in active Agile collaboration and problem-solving activities driven by design thinking, rhetorical awareness, and multimodal composition frameworks.

To help students understand the goals of this course, I presented Selber and Johnson-Eilola's (2013) problem-solving characterization of technical communication and asked students to relate their personal experiences in using technical genres and processes as a way to solve user problems. We then considered the need for creative and effective approaches to problem solving, which gave me an opportunity to introduce terms like "Agile," "design thinking," "rhetorical awareness," and "multimodal composition." As with all technical writing and communication course taught through our department, this course is underscored by the rhetorical tradition. Figure 32 below was included in the course syllabus to help students see these key emphases of this course.

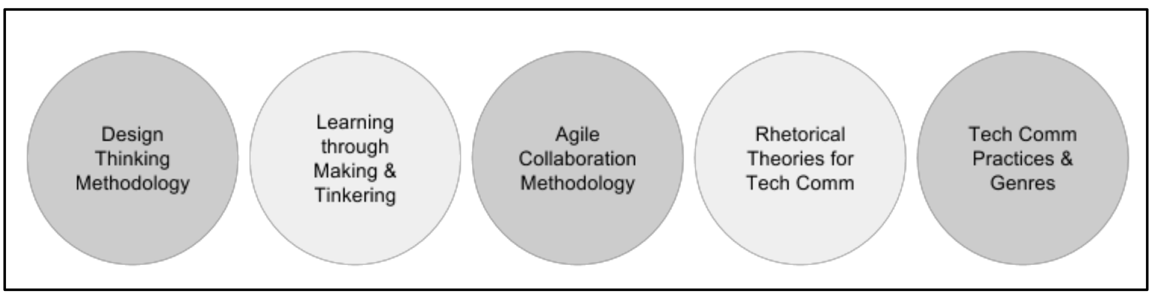

Figure 32. Key emphases of WRIT 3562W Section 009, Fall 2017.

To orient students to thinking about making as an approach to learning, I compared the writing-to-learn[34] ideas with "making to learn" through a Design Challenge project. The following masthead was on the homepage of our course Moodle page. I also provided students with some examples of design challenge student projects I have learned about from other makerspaces, such as the campus sustainability challenge that students at Design U (UMN) have worked on, the baby strollers redesign and shoe insoles projects by students at Invention Studio, and the fashion design project by students at Think[box].

[34] See "What is Writing to Learn?" by the WAC Clearinghouse: https://wac.colostate.edu/resources/wac/intro/wtl/

Figure 33. Masthead for the Design Challenge class project.

Apart from making, this course was also informed by Agile collaboration methodology[35] to help facilitate team based learning. I will discuss this process in the next few pages. Table 4 is included in the syllabus to summarize the technical communication genres and processes they will practice as part of the course.

Table 4.

Major technical communication genres and processes included in my WRIT 3562W.

Genres	Processes
- Analytical report	- Peer review
- Technical definition & description	- Agile collaboration
- Visualization of data and findings	- Usability testing
- Instructions set	- Professional presentation
- Proposal	- Professional correspondence

6.1.2 Major assignments and design challenge

To facilitate maker practices in this course, and to ensure students still receive the required learning outcomes determined by the department and the university, I have designed the following major assignment sequence for my WRIT 3562W. See Table 5 for

[35] See https://cla.umn.edu/writing-studies/news-events/news/agile-writing-project

a summary for the assignments, including their respective descriptions[36] and grade percentage weight.

This assignment sequence is made to enable a semester-long Design Challenge that is modeled after the design thinking methodology as shown in Figure 34.

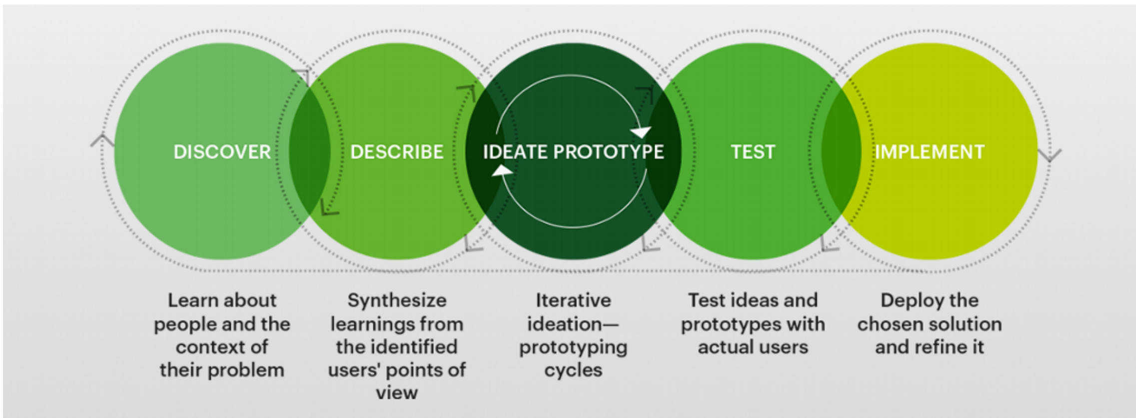

Figure 34. The design thinking process informing the Design Challenge and assignment sequence in WRIT 3562W.

The prompt for the Design Challenge reads:

> Your team will learn about the experience of students in the UMN campus community and identify a potential problem they face in a specific domain of the campus experience (see Figure 35). You will define this potential problem and ideate a viable solution to address the problem. You will create a prototype for your proposed solution, which you will use to test with actual users. Finally, you will present your idea with details on the costs and benefits for implementing your proposed solution in context.

[36] More detailed descriptions for each assignment are included in Appendix X.

Table 5.

Major assignment descriptions and weight in percentage.

Assignment	Description	Weight
Analytical report (3 weeks)	Students will identify a problem on campus that could be addressed with existing/emerging technologies or technology-enhanced processes. Through observation, analysis, and data collection (such as qualitative interview, survey, and content analysis), students work in teams of three to identify a wicked problem within the campus community, determine researchable questions, and ideate ways to address their research questions. The goal of this 1000-word report is not to solve the problem per se, but to initiate a plan for a semester-long multimodal project.	15%
Technical definition and description (2 weeks)	In a 500-word memo, each student team selects a technical term pertaining to their design project, and provides a concise definition of the specialized term. The definition should be accompanied by a detailed explanation of objects, places, or processes as the description of the technical term.	10%
Proposal of solution and prototyping (6 weeks)	Each student team proposes a solution to the problem and/or research question they have identified in the analytical report. This 1000-word proposal of solution should be written with a specific audience in mind. The proposed solution must be prototyped either in a digital or physical form. The prototype must be turned in to the instructor and will be presented to the class at the end of semester.	25%
Instruction set (4 weeks)	Each student team will organize and write an instructional procedure to enable a specific audience for	15%

	the proposed solution of the identified problem. The instructions set must have at least 20 steps, include at least 5 visuals/illustrations, list the materials required, and include a warning/caution step. This set of instructions will be tested on by at least two users. The final instructions set should reflect revision based on the results of usability tests.	
Presentation (2 weeks)	Each student team will organize and deliver a 15-minute professional presentation about their identified problems, design/prototyping processes, proposed solutions, and final prototype.	10%
Reflections (1 week)	Each student produces a 500-word reflection narrative about their learning experience with the assignments sequence and the semester overall.	5%

Figure 35. Potential focus areas for the Design Challenge.

Essentially, students were put in teams of three and asked to work with the same teammates throughout the semester to:

1. Identify a campus experience problem
2. Define the potential problem
3. Propose a viable solution to address the defined problem
4. Ideate and create a prototype of the proposed solution
5. Test the prototype with actual users
6. Present a plan for implementation with costs and benefits of the proposed solution

The major assignments above corresponds with the Design Challenge in the following manner:

Discover/empathize → Analytical report

Describe/define → Technical definition and description

Ideate and prototype → Proposal of solution and prototyping

Test → Instruction set (includes usability testing)

Implement/present → Presentation

Unlike the usual assignment sequence used in many other WRIT 3562W sections, where the analytical report is the big, final research project, I have modified it so it comes as the first major assignment for my students to begin locating the potential problem areas and specific issues faced by the campus community. Using Figure 35, students began to brainstorm ideas in their assigned teams in the first week. I have also conducted a design thinking orientation[37] to help expose students to the design thinking process and ways to think radically about problems and potential approaches to addressing them.

I have emphasized to my students that the problem area they look at should deal with an *experience* issue—like the experience of dining on campus, or using the shuttle systems—rather than having to do with *personnel*—like the university president, or a professor. The specific problem should also deal with *technological* issues, that is, it needs to be a problem that can be addressed with changes (or addition) to its existing

[37] See a report on this activity on the Wearables Research Collaborative blog page: https://wrcollab.umn.edu/news/design-thinking-orientation

technological design. Students were made aware that they need to devise and create a prototype for their proposed solution, thus they must consider the available resources for doing so. During the semester, I have included two makerspace demos to introduce students to the makerspace resources they could use. The first demo was carried out by Samantha Porter and her team from the LATIS Labs[38]. She visited one of our class sessions and introduced students to 3D imaging and printing, 360º image and video capturing, and virtual reality technologies such as HTC Vive and Steam VR (see Figures 36 and 37). The second demo was carried in the Earl E. Bakken Medical Devices Center[39]. My students visited the facility and was given an introduction to the prototyping tools in the facility by a staff member.

Figure 36. Samantha Porter and her team leading a demo during a WRIT 3562W class session.

[38] See https://labs.dash.umn.edu/
[39] See http://www.mdc.umn.edu/facility/tours.html

Figure 37. A student trying out the VR headset while Samantha Porter was giving a brief explanation of VR technologies.

Students were told to be cognizant of the human-centeredness of their proposed solution. I reminded students that they would be testing their design prototypes with actual users, thus should always be thinking of their working problems from a user's point of view, rather than just focusing on the systems or technologies. They were encouraged to reach out to various audiences of their proposed solutions—students, administrators, other stakeholders–-who might provide useful insights to help with their design solutions.

Finally, I have informed my students about the Agile collaboration methodology they would be following through throughout the semester. The Agile methodology is developed to enable student writers to work more effectively in teams. It includes regularly scrum meetings, updates, sprint plannings, and retrospectives (reviews). Most of the students had no previous experience with the Agile methodology and had no resistance toward it. I spent one week—two class sessions—in the first part of the semester training my students on the specific processes in Agile so they could employ it for the Design Challenge.

6.2 Makers in WRIT 3562W

Twenty-four students enrolled into my WRIT 3562W, and all of them remained in the course throughout Fall 2017. According to my class roster, the students enrolled in the course represented five colleges at the university, with the largest population from the College of Food, Agriculture, and Natural Resource Sciences (CFANS) and the College of Liberal Arts (CLA). Majority of the students are juniors (17 of them). Table 6 and 7 show a breakdown of the number of students by their college programs and academic level.

Table 6.

Number of students by college and their programs.

College	Programs	# of students
College of Liberal Arts	Bachelor of Individualized Study (BIS), Physiology BA, Dance BA, History BA, Communication Studies BA, Technical Writing and Communication BS, undeclared	7
College of Education and Human Development	Business and Marketing Education BS, Human Resource Development BS, Family Social Science BS, undeclared	5
College of Food, Agriculture, and Natural Resource Sciences	Animal Science BS, Applied Economics BS, Agricultural Communication/Marketing BS	8
College of Science and Engineering	Electrical Engineering BEE, Statistics/Management BS	2
College of Continuing Education	Inter-College Program BS	2

Table 7.

Number of students by academic level.

Level	**Number of Students**
Sophomore	1
Junior	17
Senior	6

6.2.1 Students' initial attitudes

By the means of a pre-course survey, I have collected students' initial confidence level for technical writing and attitude toward working in teams. Students completed this survey during the first week of the course. The survey asked students to rate their agreement to the following statement using a 4-point scale (1-4; 1=strongly disagree, 4=strongly agree).

- Statement 1: I am confident in my technical writing abilities.
- Statement 2: I think what I learn from other students in class makes up a significant portion of my education.
- Statement 3: I am confident in my ability to complete writing projects on time.
- Statement 4: I am comfortable working on group writing projects.
- Statement 5: I think working in writing teams is rewarding.
- Statement 6: Team writing motivates me to be a better writer.
- Statement 7: Working in writing teams improves my ability to meet deadlines.
- Statement 8: Working in writing teams improves my ability to meet document-length requirements.
- Statement 9: Working in writing teams helps me improve the quality of my writing.
- Statement 10: Working in writing teams increases my productivity.

Table 8 shows the mode, median, and mean results to the pre-class survey. The result of this pre-course survey revealed that students were considerably confident in being able to in completing their assignments on time (S3; mean 3.52, mode 4.00) and comfortable with working in team (S4; mean 3.22, mode 4.00). They also reported high agreement with the statement that working in teams would increase their individual productivity (S10; mean 3.13, mode 4.00). I was not surprised by this outcome since this was a 3000-level course. I have expected students to have some experience with working in teams prior to my course.

When I introduced the Design Challenge and the assignment sequence to the students, they appeared interested and curious. I received about three comments in class about students' uncertainty in completing the Challenge as they were unsure if they could locate a viable problem to address. I then reassured them that I would guide their problem-finding journey and help them to narrow broad questions. One student reported that she was not sure if she would be productive working in a team of three students. She wondered if she could work alone instead. I gave restored her confidence by letting her know that the Agile collaboration methodology is designed to help teams achieve accountability and build trust among members. She responded that she would give this Design Challenge a try.

Table 8.

Students' rating of confidence and team working attitude in a pre-course survey.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Mean	2.52	3.00	3.52	3.22	2.96	2.87	3.00	3.04	3.17	3.13
Median	3.00	3.00	4.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Mode	3.00	3.00	4.00	4.00	3.00	2.00	3.00	3.00	3.00	4.00

(1-4; 1=strongly disagree, 4=strongly agree) N= 24

6.3 Student projects

It took the students about three weeks, as part of their analytical report assignment, to choose the problem area where they would like to dedicate their whole semester to investigating. Most student teams were able to locate an initial problem/issue right away. I met with two teams to help them narrow their search during the first three weeks. Once they have identified their potential problems, students looked for relevant literature that inform them about the possible sources of their respective problems, current work or conversations around these problems, and brainstormed ideas for a research question.

Once each team has created its research question, the members then devised ways to collect data to better understand the context of the problems they were addressing. I kept reminding students that the goal of their analytical report assignment was not to *solve* the problem they were working; rather they should aim to *understand* the problem as much as possible—particular the local context and culture surrounding the problem. For example, a team that was working on campus safety issue focused on night-time assaults that students experience on campus. They had to identify the different kinds of students who have reported these assaults in the recent months, when they reported, where they lived, what they were doing when assaulted, who assaulted them, etc. Most teams used survey and interview methods in addition to secondary literature search to help them understand their problems. The analytical report concluded with findings that would guide the teams to initiate a plan of proposal to solutions that might address their problems.

In the second assignment, students chose technical terms that could benefit from detailed explanations so that different readers may understand the problems they were working on. Terms that teams worked on included:

- “Subsidized campus student housing”
- “Campus nighttime safety”
- “Campus parking services”
- “Campus navigational services”

The next assignment was considered the "meat" of the course for my students. They spent a total of six weeks completing the assignment, beginning with proposing a few ideas to address the problem each team had been working on. I met with each team in class as well as out of class to discuss their ideas. At the start of this assignment, students were also introduced to two digital prototyping/wireframing platforms—Moqups (www.moqups.com) and Balsamiq (www.balsamiq.com)—as well as a collaborative design and user-testing tool, Invision (www.invisionapp.com). Students were encouraged to use these tools to guide their initial prototyping for their proposed solution, along with the resources made available to them via LATIS Labs (Emerging Technologies and Creativity Lab, Advanced Imaging Service for Object and Space Lab, etc.) and the Earl E. Bakken Medical Devices Center.

I followed my students closely in their prototyping journey. Most teams began with proposing an overhaul to the major systems within which their problem occured. They soon learned that it didn't help with their assignment if they don't choose a specific technology to change, replace, or add. Teams shared versions of their ideas with me each week during the third assignment period. By the end of it, all of the teams had solid recommendations to address the problems they were working with. They wrote about these recommendations in their proposal and submitted the written portion of the proposal while still refining their prototypes.

I allowed the teams to make improvements to their prototypes even after the written proposal was due but reminded them that they would use their prototypes in their next assignment, the instruction set, whereby they write a user manual and test it using the prototyping with actual users. This meant that at some point the teams had to decide on a "final" version of their prototype in order to use it in their usability tests. Each team completed at least two tests of their user manual and prototype with students they had identified to be potential users of the recommended solution. Following the testing sessions, each team produced an updated manual and turned them in.

The last assignment students worked on in their teams was the presentation. Prior to the presentations, I met with each team one last time to assess their progress. Then, starting in the first week of December, we held four days of presentations where students shared their research journey—from determining their problem area, to naming the technical term, to ideating solutions, to designing and developing prototypes, to testing with users. As part of the requirements of the presentation assignment, each team also explained the final costs and benefits of implementing their proposed solution. Table 9 shows an overview of all the team projects for the Design Challenge—their respective problem areas addressed, proposed solutions, and prototypes.

Table 9.

Overview of Design Challenge projects and outcomes.

	Problem Area	Proposed Solution	Prototype
Team 1	The lack of flexibility in meal plan spending options and students' unhealthy dining behaviors.	"To implement a points system in the dining hall using a device called PointPost. Each station in the dining hall is allotted a certain amount of points. Users have the option to view their point balance through an app called NextJEN PointPost. Students will have more control over their spending habits, and will only grab food that they wish to eat."	*PointPost* - a scanning station for meal points.
Team 2	The lack of certain nutritional options in the university dining halls.	"The idea of the application is that students may forfeit a 'meal' from their meal plan in order to procure groceries and in so doing, would have a small amount of their meal plans cost credited back to them."	*Gopher Grub* - an application for tracking one's nutrients and reward them financially for logging their die
Team 3	The lack of navigational tools offered to find one's way around our massive, 3-campus university.	"360 degree, interactive views of both indoor and outdoor pathways and areas are implemented within the interface, enabling the user to find physical markers within the building to aid in recognizing the space they are locating."	*MapIt* - an app with real-image mapping for indoor and outdoor navigation.

Team 4	Campus night-time safety concerns.	"The installation of campus Help-U with U-Travel interactive displays in strategic locations of university properties to effectively connect distressed students and other members of its community to a friendly, system that serves as accessible navigational service."	*Help-U* - a website to aide in building/ campus navigation, monitoring, and dissemination of building information for University of Minnesota patrons. *U-Travel* - a centralized website for three University sponsored websites: Parking and Transportation Services, Public Safety and the U, and Safe-U. A digital display to feature Help-U and U-Travel.

Team 5	Overpriced luxury student housing that limits students' off-campus housing options.	"An apartment complex with a focus on practicality and opportunity for student-subsidized rent."	*H.A.M. Student Housing* - a website for scheduling a tour, applying for a lease, applying for a job within the complex, tabs for overseeing rent subsidization, as well as pages that allow potential residents to view floor plans and read about the housing provider's mission.
Team 6	Expensive campus parking costs and penalties.	"Our group thought prototyping kiosks around parking ramps, lots, and garages would help university students avoid unnecessary payments."	*Tiki* - a digital ticket counter that sends parking tickets to user's mobile device.
Team 7	Commuting students pay expensive campus parking.	"Our proposed solution is to create a collaborative mobile application between Uber and University of Minnesota."	*M-Uber* - Just like Uber but with

			additional features that benefit University of Minnesota students.
Team 8	Difficulty in locating available parking spaces around campus.	"To improve experience with real-time viewing of parking spaces via color coordinated map, various maps covering East Bank, West Bank and the St. Paul campus, and cheap & convenient mobile payments."	*ParkSmart* - an app with real-time display of parking availability around three university campuses.

6.4 Student responses and reactions to the course

To capture the students' learning experience in this maker-based WRIT 3562W, I have used a set of data collecting tools. Here I present my findings from a comparison of pre- and post-course surveys, student reflection essays, RATE assessment, team and individual interview responses, and lastly, student rating of teaching (SRT).

6.4.1 Changes to confidence and team working attitude

By the end of the semester (Week 13), students completed the same survey they did in the beginning of the course. Table 10 shows the results of the second survey. Table 11 shows the percentage of change from the first to the second survey.

According to Table 11, all ten statements received a positive change (increase) in their ratings. This means that students reported higher agreement to all the statements in the second survey. The greatest change in percentage for mean score is found in Statement 1 (on students' confidence in their own technical writing abilities) at 32.18%. The greatest change in percentage for mode is found in Statement 6 (on team writing motivating students to be better writers) at 100.00%, from 2 (disagree) to 4 (strongly agree). These positive changes are an early indication that students had a positive experience in this course. However, the survey results do not provide any examples of student learning. To gather these reactions, I look at students' reflection written in the essay form.

Table 10.

Students' rating of confidence and team working attitude in a post-course survey.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Mean	3.33	3.04	3.92	3.42	3.33	3.21	3.46	3.46	3.33	3.54
Median	3.00	3.00	4.00	4.00	3.50	3.00	4.00	4.00	3.00	4.00
Mode	3.00	3.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00

(1-4; 1=strongly disagree, 4=strongly agree) N= 24

Table 11.

Percentage (%) of change from pre-course to post-course survey results.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Mean	32.18	1.39	11.21	6.19	12.75	11.81	15.28	13.63	5.02	13.14
Median	0.00	0.00	0.00	33.33	16.67	0.00	33.33	33.33	0.00	33.33
Mode	0.00	0.00	0.00	0.00	33.33	100.00	33.33	33.33	33.33	0.00

6.4.2 Student descriptive experiences

Like the pre- and post-course surveys, students wrote about their experience with collaborative learning in reflection essays at the beginning and the end of the semester. In Week 1, students were asked to describe their experience with collaborative learning as either very negative, negative, positive, or very positive. They were asked to provide specific examples to support their responses. Again, in Week 13, I asked students to describe their experience but this time basing it off their experience in this course. In Table 12, I compare student responses from Week 1 and 13 numerically (1=very negative, 2=negative, 3=positive, 4=very positive).

Of the 20 valid responses, only one student (17C) reported a decline in his/her experience (from very positive to positive). Of those 20, a total of 11 students had at least positive experience in collaborative learning at the start of this course. Out these 20 students, 17 of them reported at least positive experience at the end of the course. Nine out of these 20 students had experience a positive change in their experience, either from negative to positive (six), or from positive to very positive (three). Three students remained having a negative experience—all three of them reported negative experience for both before the course as well as after the course.

Table 12.

Percentage (%) of change in students' experience with collaborative learning from Week 1 to Week 13.

Student	**Week 1**	**Week 13**	**% change**
1C	3	4	33.33
2C	3	3	0.00
3C	2	3	50.00
4C	2	3	50.00
5C	3	4	33.33
6C	2	2	0.00
7C	2	3	50.00
8C	3	3	0.00
9C	3	4	33.33
10C	2	3	50.00
11C	N/A	N/A	N/A
12C	N/A	3	N/A
13C	3	3	0.00
14C	3	3	0.00
15C	N/A	3	N/A
16C	3	3	0.00
17C	4	3	-25.00
18C	3	3	0.00
19C	2	2	0.00
20C	3	3	0.00
21C	2	2	0.00
22C	2	3	50.00
23C	2	3	50.00
24C	2	N/A	N/A

(1=very negative, 2=negative, 3=positive, 4=very positive) N= 20

The responses from the student reflection essays are mostly parallel to the survey results. Students described how the Design Challenge assignments have helped them learn to work in teams. The following responses note the importance of empathy, openness to others' ideas, and synergy:

> "Working with people from a multitude of disciplines, skills, and schedules is a challenge for anyone. For college students, our investments are spread out, therefore, genuine 100% commitment is hard to come by. We were all guilty of this as a team. However, with empathy, honesty, and perseverance we ended up making a good team when it came to assignment development and submission."

> "Working as a team to determine how we can improve campus health and wellness brought up many points and ideas I hadn't thought of. It was interesting to hear personal experiences of living in the dorms and different reasons why people had issues with the dining hall. Many people said that they had very few vegetarian and vegan options. I never lived on campus but I struggled with this just during my two day orientation! I didn't realize other people struggled with that too. Working to find a solution in groups was a great experience that brought many different viewpoints and ideas that I wouldn't have thought of by myself."

> "Even in the most trying of times such as the week before the proposal was due, the energy was either high or contagious and the plans were always thought out well. I regret to say that I believe I will never experience such a team dynamic as this year's."

> "During the proposal and prototyping portion of this class we all came together and played to our individual strengths and weaknesses. Tushar was very interested in working on the prototyping itself because he enjoys photography in his spare time, Rachel took on the task of designing the interface because she is very

> interested in virtual design. I worked on the cost/benefit analysis and the rest of the paper because I enjoy analyzing the business and monetary side of things."

Some students have also pointed out the role of the instructor in facilitating the assignments:

> "I was continually awed by the instructor's inspiring enthusiasm for the course and his unique, eye-opening methods of problem solving and solution seeking. The project itself was one of the most rewarding, interesting, and refreshingly relevant things with which I've been tasked in my college career."
>
> "I can tell that Jason was very intentional in designing this project around teams, the group writing process, and simulated real-world collaboration. With that, I was presented a crippling, sometimes downright distressing challenge this semester that only now I can say made me a better person."

For one student, the projects have opened her up to a different way of seeing problems and possibilities:

> "In hindsight, I'm really glad I took this class. There were many sections from which to choose, including sections located much closer to where I live, and even an online option. I learned about so much more than just writing in this course. It was refreshing to focus on something productive outside of myself. Listening to Jason was inspiring. It motivated me to change the way I think about problems and the world around me. There are a million problems in the world, but sometimes the solution is living in a box in our mind that we just haven't opened. It required a change of perspective … For me, this class went beyond "learning objectives". I learned about myself, and remembered that even if I can't change the circumstances, I can always change my outlook."

Finally, students have detailed their design and prototyping process, highlighting how that has helped them learn research skills, especially with data collection. Some students have also related this experience directly to a TPC learning outcome that is teaching students to be user advocates:

> "This semester I helped my group out on developing the "M Uber" app. With help from the professor and my group we decided to create an app that utilizes ridesharing and helps eliminate the issue of parking on campus for commuter students. To do this I spearheaded to research portion of this idea. I had to research the history on ridesharing and campus parking costs in order to make this app reasonable and a better option than the current parking options. I had a lot of fun doing this and was happy that I could contribute to my group in an effective way."
>
> "Throughout the semester, I found myself being the member of the group that did most of the research and critical thinking. I enjoyed researching other universities and schools and trying to find a solution to our meal plan system that was like others, that students were more pleased with. It was also extremely interesting to me to create an app based on our solution. Although it was hard work and difficult to work the technology, I appreciated the challenge."
>
> "After we determined to deep delve nighttime safety facilities on campus, our team developed a detailed plan with several methods to gather information. First, we searched online to view what current services the University of Minnesota provides. We also researched related resources of other universities at the same time for future use. After knowing the current facilities, we created a survey for students so as to know their needs of safety during night. We tailored the survey as the project needed then reached out as many students as we could. Also, we interviewed related departments as well as working staffs to know their options and suggestions. With all the information we collected, our group narrowed down our topic and potential solutions successfully."

Taken together, these descriptive responses paint a positive picture representing the overall student experience with the course.

6.4.3 Student self-assessment

While student responses through interviews and surveys are valuable, they are often too open-ended. To help students reflect on their learning experience through a language that focuses on student learning outcomes, I turned to an assessment tool administered by our College of Liberal Arts called RATE (stands for reflecting, articulating, translating, and evaluating; available at https://rate.umn.edu/). Figure 38 shows a screen capture of the portal.

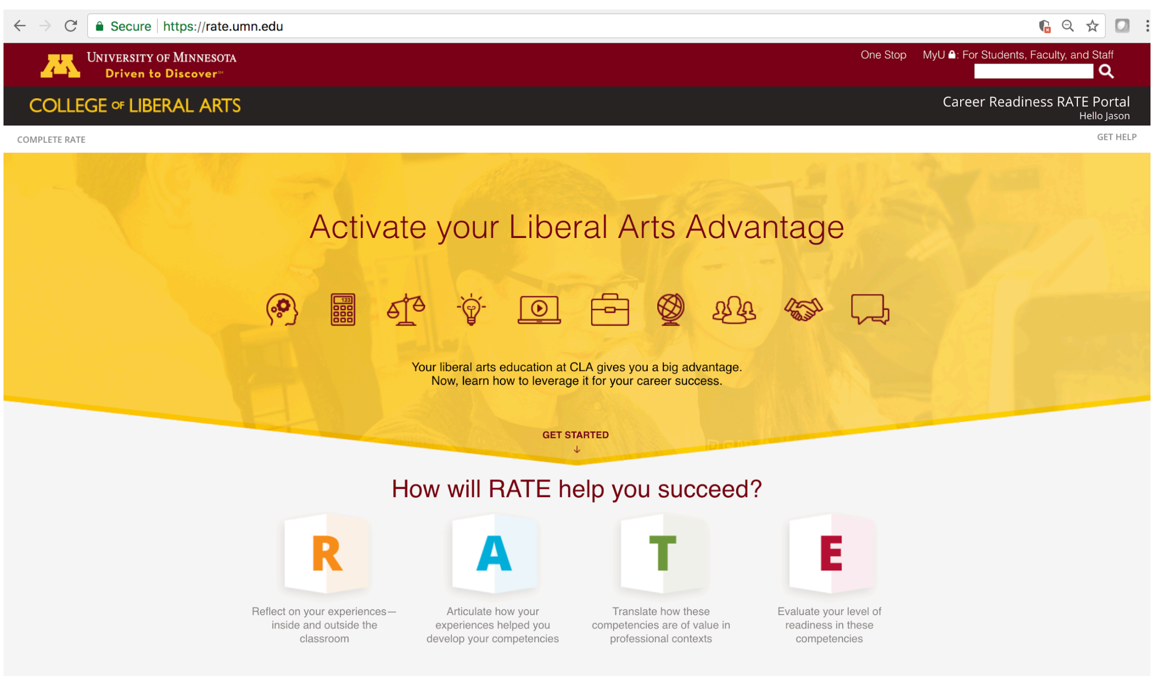

Figure 38. Screenshot of the College of Liberal Arts RATE portal.

Using the RATE tool, students were asked to name at least one of the 10 CLA Core Career Competencies[40] they believed they had achieved through this course. Fourteen students completed this self-assessment. When completing the assessment, students were asked to provide examples from the course that are representative of the core competency they said to have learned.

Two students chose "innovation and creativity" and "digital literacy" respectively. One of the students noted her ability to learn a specific technology quickly:

> "I was at an interview just the other day and I was asked about a successful group project I was in, and without hesitation, I spoke about this one. I talked about the background of the project, and the prototype I created … It shows I can take on new forms of technology and learn them quickly."

Three students chose "applied problem solving," and stated how the Design Challenge project helped them learn ways to approach problems, including ambiguous ones:

> "This class showed me that it may take some time to come up with an appropriate solution to a certain problem, but that it is beneficial to talk to other people, brainstorm the possible solutions, talk about which is the best, and go from there."

> "In future employment, I will be asked to solve a problem at times with not a clear-cut way to get there … I believe that my experiences working in a team setting while being creative will make me a valuable candidate because I have experience growing in this area."

Two students said "oral and written communication" was what they learned most from this course. One of the students noted in detail how he practiced audience analysis and strategic communication through the project:

> "Without a doubt I believe I practiced the intentional engagement of audience—the students and community leaders—for the purpose of specific goals, which

[40] See https://cla.umn.edu/academics-experience/signature-cla-experiences/career-readiness/core-career-competencies

were to inform them of the current safety situation of this campus and to convince them that a wireless platform like the one we propose was not only practical, but useful, and necessary. To address these audiences we had to consider our relationship with them and the social and political context in which we interact, as well as the needs, goals, and motivations of all parties. Some of the challenges that we met with methods of communication included the lack of digital accessible information on the U's electronics management, safety personnel, and application development process, so we met these challenges with both in-person and professional over the phone group interview styles with the accompanying email coordination. For each individual with whom we spoke, we adjusted our language and topics of conversation based on the relevant technical and professional standards."

Four students chose "teamwork and leadership" as their core competency. A representative response noted how students learned to recognize each other's strengths to contribute to different sections of the project:

"The interesting aspect to the teamwork and leadership skills built this semester was that there was no specific leader for this particular project. We were able to work off of one another and recognize our strengths for each section of the project. We basically rotated the leadership role depending on the part of the project we were on. One group member was better with technology and development, another with writing and forming cohesive thoughts, and another with brainstorming. We were able to develop roles in responsibilities from the beginning by identifying our strengths and rolling with it. But this is not to say that we stuck with our individual roles and that was it. We all contributed to different aspects of the project."

Two students chose "analytical and critical thinking," and reported how this project has helped them see problems from multiple perspectives:

> "This course and the project around which it was structured was highly student-driven. This experience made me much more visually, and practically aware of my surroundings. It provided me the basis to see and think about challenges on campus and in my own life, differently. I learned to change my thinking style to more radical than conservative when trying to think of a solution to a problem, and helped me develop skills to work on a team and bounce off of others' ideas."

One student said it was "engaging diversity" that she learned from her project:

> "Engaging diversity in our project wasn't that hard to come about. For my groups project we created a prototype for less expensive campus housing. When working on this we have to look at the university as a whole and think about all of the different types of humans we have on this campus and think about everyone's unique background. We made our website very easy to use which will allow all types of people to feel comfortable with it."

The RATE tool allowed me to see how the maker-based course benefits students in terms of TPC objectives but also translates into career readiness competencies.

6.4.4 Feedback from individual and team interviews

After the completion of the course, I made an open invitation to welcome students to share their experience with me face-to-face in the form of interview. One female student and a team of three students volunteered to meet with me. I conducted an individual interview with the female student and a group interview with the team.

The student who completed an individual interview with me, Hannah, was an animal science major who took this course to fulfill her upper-division writing-intensive requirement in the major. During the interview, she spoke mainly of the Design Challenge as a whole and why she thought it was a valuable experience. First, Hannah noted the ambiguity in the challenge and how that inspired her and her team to approach problems that were outside her immediate experience:

> "I enjoyed the ambiguity and creativity to pursue a project we wanted, within reason. For the most part I enjoyed working on the assignments. They were very intentionally designed to be a team-based. It is hard to do everything by yourself, especially if you don't have the skills necessary to solve the problem."

> "I didn't actually pick our topic but I ended up liking it a lot. It gave us a lot to talk about. It was related to living on campus. I have never actually lived on campus."

When asked about her learning experience, Hannah said she practiced applied problem solving through making an actual prototype to address the problems at hand. She also noted that she learned the importance of organizing a workflow so her team could stay on schedule:

> "I would say the website that we built was an example of the most applied problem solving activities I have done in any class. It was the first time I have made something that users would potentially use, and it had to be functional enough. I have never done anything like that in any other classes. In my head, when the project was assigned, I had no idea how I was going to be able to do that by myself."

> "The most challenging assignment, for me, was the proposal and prototype assignment. Most of the other assignments were built around the prototype and how it works, how users would operate within it. But we didn't have our prototype made until a few days before we had to turn in the proposal. So writing the proposal before having the prototype in hand was difficult. And then the instruction set, too (needed the prototype). As the proposal assignment was wrapping up we were writing the instructions for using the prototype but we wonder how were we going to do that without a full prototype."

Hannah admitted that when her team realized the scope of the project required expertise they do not possess, they consulted external support:

> "My friends who had specialty in making websites helped me. My parents and friends helped read our proposal."

I also asked Hannah what she thought about the level of instructor's involvement and team autonomy during the Design Challenge, she said she enjoyed the freedom her team got to work on their own, but also appreciated when I checked in with them because it allowed them an opportunity to clarify the status of their project:

> "The less instructor's involvement in our team activities, the more freedom we have… I think that is one of the most valuable things about the assignments. But when you came over to our group in class to ask us about updates, we could all gauge our knowledge of our project, and I liked that. That interaction was helpful in a lot of ways—not only that you get to know what's going on, we all got to get on the same page about what was going on."

Hannah had the following advice for future students who might work on a similar project:

> "First of all, set up a communication method right away. I hear other teams saying the same thing as well. Also, keep up with the assignments and don't let yourself get behind. The assignments do build off of each other. If you don't have a prototype, you're not going to be able to make an instruction set."
>
> "We had a group messaging system that worked well for our collaboration. I send out weekly updates to my group about where we were at and what needed to get done. Along with the taskboard[41], I was doing these other things to be effective."

Finally, Hannah shared a sentiment that I agreed to be a key distinction to learn from the Design Challenge:

---

[41] A kanban-style table with three columns: to-do's, in-progress, and done.

> “We have more than enough people in the world who *talk* about problems, we need more people who can *solve* them.”

The most important takeaway from my interview with Hannah was getting to know how a student negotiated her way through a wicked problem that was unclear to her and her team at first. I have learned from this individual interview that one key attitude to cultivate is to embrace ambiguity; while dealing with ambiguity, Hannah and her team demonstrated flexibility and willingness to ask for help from external sources.

In a separate session, I met with three students who were assigned to the same team for the Design Challenge. Two of these students were female (Sheryl and Shelby) and one male (George). George was pursuing a bachelor of independent studies while Sheryl was an economics and actuarial science major, and Shelby was a health management major.

At the interview, these students were asked to share what they found valuable in the course through the Design Challenge and what were some challenges they faced. Sheryl responded first by saying that the Design Challenge helped her understand concepts from the course textbook:

> “Sometimes reading the textbook might be dry and boring. The activities we did in class and in my team helped me comprehend the textbook better.”

Shelby said that she learned to apply the design thinking methodology from an initial orientation to her team project, as well as seeing other team’s design process:

> “In the beginning I wasn't quite sure what the design thinking activity was about but as the semester went on I was able to see what you were trying to get at. I also thought it was cool to be able to see what the other groups were doing not really giving out exactly everything but a preview. So I thought to myself that is so cool what can we do that is like theirs and how can we make ours different at the same time.”

In terms of challenges, Sheryl said that her team learned to reach out to outside support when they were not able to address the research problems on their own:

> "I think one of the challenges is that our abilities are limited. When we were exploring the solutions. We came up with several plans. When we consulted external sources, we realized that our solutions weren't good. We didn't have money, we didn't have enough time. So that took us even more time to figure out other solutions. Given our own schedule, time management became a big challenge for all of us."

George, too, agreed that time was a challenging factor:

> "We had so much that we came up with so we're having a hard time narrowing down to one thing to do. So if there were more directions on the parameters of the project it might have been helpful."

Additionally, students also talked about how they might benefit from sharing with one another in the team their individual strengths and weaknesses in the beginning of the project. George noted the importance of not just giving one another tasks they think they were good at:

> "If we only focused on our strengths, I don't think I would have developed areas that are my weaknesses."

Sheryl said that she learned how to write better from looking at George's writing. She also highlighted that she had learned more about technical writing from the Design Challenge project:

> "Because of this course, I now have a deeper understanding of technical writing. I know how to identify a problem, describe it, and gather information and data, and come up with a conclusion about the problem or recommend solutions."

George then noted that the instructor's role in connecting students with various campus resources was key to the success of their team's project:

"Your (the instructor's) work to connect us with different resources on campus was very awesome. That's a lot of work, it seems like, for you. But it definitely was helpful."

Sheryl agreed, and added that her team learned to take the initiative to find resources that are related to their own project:

"I think it is also important for students to reach out to units and departments that are pertinent to their own projects because the instructor is not that magic and he can't do everything."

George: "The people that we reached out too were very willing to help us. Almost too willing [laugh]. Except the police department; they weren't too willing. They had a lot of stuff going on. But others have a lot of stuff going on too. I was surprised that they were willing to support us."

When asked for advice to future students, Shelby recommended:

"Be open. Be open to others' ideas. Just realize that you are not always right. Don't be caught up in just what you do because there are other ways to doing things. That's a good way of learning."

Sheryl added:

"I suggest being proactive. You have to be responsible to your group partners. The most important thing to me is learning from others."

Finally, George said:

"This may go without saying, but really be open in terms of communication. Making sure that your team in on the same boat. It helped us, I think, it wouldn't have worked out for us if we don't know how many other things one has going on."

From the team interview, I have learned that students found the Design Challenge to be an opportunity for them to practice collaborative problem solving. Similar to Hannah's experience, Sheryl, Shelby, and George recruited outside resources to aid their project when they realized they do not have the necessary knowledge or expertise. It was encouraging to hear students reiterate the design thinking methodology in their responses, like understanding users and iterating design.

6.4.5 Student rating of teaching (official course evaluation)

Lastly, I turn to students' evaluation of this course, the official Student Rating of Teaching (SRT) responses to identify the value of the maker-based TPC course. According to the University of Minnesota's Office of Measurement Services, which is responsible for collecting and aggregating SRT results, "The SRT is expected to improve how teaching is assessed by students and help instructors better understand how they can improve their teaching. The SRT results are linked to the University's Student Learning Outcomes (http://www.slo.umn.edu)." For the purposes of this section in the dissertation, I focus on Section 2: Course Ratings. This section contains six questions for students to rate their course and an open-ended question: "What suggestions do you have for improving this course?" Table 13 shows the results from the first five questions. Results from Question 6[42] is omitted because it does not pertain to the focus of this section.

[42] Question 6 asks, "Did you take this course because it was required or was it an elective?"

Table 13.

Students' rating of five course-related item in mean and median, and the total number of responses per question.

Course items	Mean	Median	# of response
1. I have a deeper understanding of the subject matter as a result of this course.	5.00	5.00	22
2. My interest in the subject matter was stimulated by this course.	5.00	5.00	22
3. Instructional technology employed in this course was effective.	5.41	6.00	22
4. The grading standards for this course were clear.	5.45	5.50	22
5. I would recommend this course to other students.	5.43	6.00	21
Overall	5.25	N/A	22

(1=Strongly disagree, 2=Disagree, 3=Somewhat disagree, 4=Somewhat agree, 5=Agree, 6=Strongly agree) N= 22 (Q1 to Q4), N= 21 (Q5)

According to Table 12, most students at least agree (5.00) to the five statements related to their course experience. The highest mean score goes to Statement 4 on the clarity of grading standards in for this course (5.45).

In terms of students' suggestions for improving the course, the responses included the following:

- "Make book not required - maybe ppt notes for the info? I didn't find it was worth it to buy it because I didn't use it."
- "Class time to work with my group."
- "Having more options for improving the group aspect. Some people bad interactions, there should be some type of solution for them."
- "No assignment in this class required any prior knowledge or studying."

- “Posting grades online so we can track our progress.”
- “Include more info on how to write better, not just concepts.”
- “More in-class activities.”
- “More accountability on readings. We could take class time to have group discussions and do more application assignments.”

Overall, students wanted more connection between the Design Challenge assignments, the textbook, and other reading materials used in the course. A second theme seems to emerge around the desire to spend more class meeting time on group work or group learning activities, which include applying book knowledge, resolving interpersonal issues, and working on the ongoing assignments.

6.5 Instructor’s experience

Reflecting on the course as an instructor, I note several important resources that have helped make this maker-based WRIT 3562W possible. The first is definitely the support from university units outside of my immediate department. From the get-go, I was connected with two key collaborators who saw value in the maker approach to teaching TPC; they are the university libraries and LATIS. At the university libraries, I was connected to Jonathan Koffel and his team of librarians and faculty members who were studying makerspaces. Before launching the two new makerspaces (Makerspace in the Biomedical Library and Breakerspace in Walter Library), Koffel and his team have met with me to exchange ideas about the potential set up (fabrication tools to include, furniture, layout, etc.) for their new makerspaces. During those meetings, I also shared this course’s design and some teaching materials with the team. They provided feedback that helped me consider the tools to introduce to students and connections to other campus makerspaces such as the Earl E. Bakken Medical Devices Center, LATIS Emerging Technologies and Creativity Lab, and Anderson Labs. My interaction with the librarians provided insights and perspectives I do not usually receive from my disciplinary home—which tends to focus on the course content and deliverables.

My second collaborator, LATIS, was an existing collaborator even before I envisioned a course to be taught with the maker approach. My involvement in the Wearables Research Collaboratory since the start of my doctoral education journey introduced me to LATIS, some time around early 2015, when the IT arm of the College of Liberal Arts had just reinvented itself as an innovation driver (rather than being tech support to the college). My early engagement with LATIS has led me to becoming more of an insider of the services and new initiatives the unit offers. It has also introduced me to many key staff members from LATIS thus making it more effortless to request for help when I was designing this WRIT 3562W course. My main contact was Samantha Porter, who was newly hired as the graduate assistant for LATIS Labs (there are six of them) in 2017. Porter and I exchanged emails before the Fall semester and set up a support system for my students' projects in the Design Challenge. As noted in the earlier section, Porter and her team provided an in-class virtual reality demo. Beyond my expectation, Porter also met with a few student teams outside of class time to help them ideate and design solutions. At the end of the semester, three student teams explicitly thank Porter during their presentation for her support.

One of the challenges I faced during the course was coordinating student visits to the various makerspaces as well as motivating them to explore those facilities on their own. To most of my students, the idea of designing solutions to solve problem was nothing novel. They have done so in other classes in the form of research proposals and papers. However, taking it a step further and requiring students to create tangible prototypes was unfamiliar to the students' experience. I was met with some resistance in the beginning of the semester; a few students came up to me and asked if they *really* needed to present something tangible in the end. I encouraged them by showing the makerspaces as resources for accomplishing the goals of the Design Challenge. That motivation was well received. Yet, once students have seen the facilities, not many teams decide they would spend a lot of time in there to do their projects. Instead, most teams retreated to online/digital prototyping technologies and meeting with Samantha Porter separately to work on their designed solutions.

Another challenge I faced was in connecting my students with student collaborators outside of the course. One of the values I would like to cultivate from the maker approach to this course is cross-disciplinary collaboration. Although students in this course were already diverse in their background and academic majors (see Table 6), they lack the opportunity to work with those from other classes who were developing knowledge in different subject matters. For instance, when designing this course, I considered working with a faculty from mechanical engineering so my students could gain experience in working with students in an engineering course. However, conflicts in class schedules and course deliverables have limited such collaboration.

Nevertheless, I have observed many positive instances of "learning in action" that reaffirmed my belief in the maker-based TPC course. Evidently, students have learned more than just "writing" in this course; they practiced applied problem solving, learned to manage a collaborative project, and tinkered with new technologies. In the next section, I preview these instances as major themes generated from the findings in this chapter.

6.6 Summary of findings and major themes

To conclude this chapter, I present Table 14 with a summary of key findings from my case study of the maker-based TPC course.

Table 14.

Summary of findings from pedagogical case study.

Method	Purpose/Measure	Results
Pretest (Week 1) and posttest (Week 13) surveys: Quantitative responses Week 1 N= 24 Week 13 N=24	Document changes in students' confidence in team projects and attitude toward team working.	By Week 13, students reported positive attitude change across all 10 measures to their experience with team project.
Pretest (Week 1) and posttest (Week 13) surveys: Descriptive responses Week 1 N= 24 Week 13 N= 20	Document changes in students' attitude toward team project; students' reactions to course design.	By Week 13, one student reported decline in team working experience but remained positive. Nine out of 20 students experienced a positive change to their attitude. 17 out of 20 students reported positive experiences with their team projects in this course. Keywords from student reflections: Empathy, openness, synergy, role of instructor, possibilities, user advocacy.

Self-assessment (RATE) N= 14	Identify translation of learning to CLA core competencies language.	Core competencies selected: - Innovation and creativity - Digital literacy - Applied problem solving - Oral and written communication - Teamwork and leadership - Analytical and critical thinking - Engaging diversity
Qualitative interviews: Individual and team	Document key learning experiences and categorical themes.	Main discussion: - Ambiguity in making leads to inspiration. - Making actual prototypes help address problems. - Consulting external support (friends, university resources). - Communication is key to team success. - Hands-on problem solving makes learning more interesting. - Seeing others' design process helps inspires one's own. - Time constraint is one of the biggest

		challenges.
Student rating of teaching (SRT) N= 22 (Q1, 2, 3, 4) N= 21 (Q5)	Document students' assessment of the course in terms of quality of instruction received.	All students rated at least 5.00 out of 6.00 to the five statements related to their course experience. Students wanted to see stronger connection between the Design Challenge and the TPC textbook. Students wanted more time in class for team-based activities.
Instructor's self-report	Document key support and challenges in the course.	Main discussion - Support from university units (outside department) is crucial. - Student needs motivation to get into actual makerspaces. - Students would like to collaborate with students who are not from their class.

Based on the responses from students and my own reflective experience on this course, I recognize three emergent themes: 1) "making" as a mindset, 2) making challenges TPC pedagogical conventions, and 3) making fosters new literacies.

While I had expected that the key factor to a successful maker experience was the technology of a makerspace, the feedback received from students at the end of the course reflected the importance of a maker *mindset* instead. In their responses, students reported that the idea of making was new to their college experience, but the use of various technologies for rapid prototyping was not something extraordinary. Most students, through other college courses, have been exposed to 3D printers, laser cutters, and DIY circuit boards like the Arduino development kit. Nevertheless, students admitted that they were challenged to maintain a maker mentality, wherein they uphold a sense of empathy toward user experience and an aspiration to keep trying new prototypes even when they have failed several times.

The maker mindset, based on the student feedback, is made up of a genuine can-do attitude that does not fear failure, but rather embrace it with a spirit of experimentation and venture. A true maker does not quit at first try. This mindset is akin to design thinking, where one practices an iterative approach to making solutions. Some students have also revealed that their peer's energy has influenced how they engaged with their own project during the semester. These students said that being around others who are driven to succeed helped them to strive for success as well. Thus, the technologies in the makerspaces do not really determine the success of a maker pedagogy per se, a student's maker mindset does.

Although the forms and features of technical writing may have evolved over the years, the conventions around teaching of technical writing have remained around some ideologies—mainly text-driven composition and independent writing. However, in most cases today, technical writers don't work in isolation, and are constantly pursuing means of communication other than printed texts alone. Further, as more and more technical writers now work with product development teams alongside product designers and engineers, they are becoming more involved in the design process. All these add to a void in most technical communication curricula today where students are not given the opportunity to practice working in teams over a sustained period of time and project.

The maker approach, then, appears to be a possible solution to bridge this void. At the end of the semester, students reported that they had learned more than just the forms of technical writing in the course. Through the Design Challenge, students said they used more than just textual elements to identify, define, and address design problems. In most cases, students pursued visual, sonic, gestural, haptic, and even spatial modes of communication. In these instances, students reported that this course has disrupted their typical understanding of technical writing, and were able to discuss why "writing" in the 21st century goes beyond just texts. Students have also described new understanding of rhetoric in material culture. Through prototyping their proposed solutions, students said they were paying more attention to the meanings of things and how different materials can be used to achieve persuasive ends (such as using lightweight materials to build smart sensors are worn on the body).

Additionally, students have reported that they find collaboration necessary in completing their Design Challenge project. They reflected on how different would it have been if they were to address their design problems independently, and said good ideas are less likely to come by. Students have also reported that they took on roles they felt they had expertise on (such as programming, graphic design, formatting papers, etc.), and that had helped them share the load in addressing the design problem. Such observation was certainly pleasing to the author as collaboration—a desired competency for technical communicators—was actualized.

Although design thinking comes with markedly straightforward steps, students in the course did not think that devising a solution for a design problem was not as linear as the design thinking methodology suggests. Many students have admitted they found themselves stuck in phases of problem identification and definition. Even when they thought they have gotten past the phase of definition into determining possible solutions for the said problem, some of the students reported they had to constantly return to earlier phases to better understand the problem. An iterative process soon became a messy process for those who felt it was difficult to keep track of the lines of thoughts/discussions that led them to their decisions for solution. Nonetheless, students reported at the end of the course that they understood design to be a continuous process without a clear-cut order. For technical writing students, this is an important distinction.

In these student responses, I have also learned that a maker-based TPC pedagogy must embrace ambiguity—since good problems are often those that are hard to define and addressed from a single perspective. With regards to this, students have reported that they felt both anxious and excited when their design solutions were tested by actual users. The testing of prototypes has led students to consider the notion of "wicked problem" in design thinking, and how there is often more than one solution to the problem. For technical writers, this can be an important mindset to cultivate given the increasing complexity in consumer culture today.

6.7 Chapter summary

As the largest chapter in this dissertation, this chapter included a thick description to the course design and assignment sequence, and details about the Design Challenge—an intentional, maker-based WRIT 3562W course I taught in Fall 2017. I have introduced the students as well as their projects. Then, to gauge the students' responses to the Design Challenge and the course overall, I have included results from numerous student surveys––pre- and post-course surveys, descriptive reflections, RATE self-assessments, and student rating of teaching—plus individual and team interviews. Juxtaposed against these responses are my own reflections as the instructor and observations that are summed up by three emergent themes of a maker pedagogy. In the next chapter, I further explicate these themes to construct an applicable pedagogical framework for designing a maker-driven course, motivating students, and assessing student learning.

CHAPTER 7
Toward Maker Pedagogy

Following the findings from my visits to three academic makerspaces at University of Minnesota, Georgia Institute of Technology, and Case Western Reserve University, and the results from a pedagogical case study of a maker-based WRIT 3562W in Fall 2017, this chapter shares a pedagogical framework devoted to leveraging maker practices for TPC pedagogical purposes. In the following pages, I discuss a maker pedagogy framework with a set of guiding principles, specific maker elements, and assessment strategies. I close by discussing the theoretical implications a maker pedagogy direction for TPC, rhetoric, and writing studies at large.

7.1 Maker pedagogy: A framework

In this section, I provide a pedagogical framework for integrating maker practices with TPC curricula. I begin with a set of guiding principles based on the derived from my makerspace observations as well as the cumulated responses from my students in the Fall 2017 course. Then, I translate these principles into a comprehensive pedagogical framework I call the Maker Pedagogy framework to be adopted in TPC curricula. Finally, I present a set of heuristics for assessing the design and effectiveness of a maker course.

7.1.1 Guiding principles

As indicated by students from the pedagogical case study in Fall 2017, and as presented in the major themes from the previous chapter—1) making as a mindset, 2) making challenges TPC pedagogical conventions, and 3) making fosters new literacies—a successful maker experience is first dependent on a maker mindset. It is essentially an attitude and venturous spirit that embraces challenging tasks and potential failures.

Therefore, the first guiding principle for maker pedagogy is to ensure cultivation of this maker mindset. Across all learning exercises, projects, and student interactions, there must be opportunities for students to cultivate empathy, experiment with multiple solutions, engage iterative design, and reflect on their experiences. This creates the first major tenet for my Maker Pedagogy framework that is **design thinking**.

Second, from the perspective of writing pedagogy, the goal of infusing TPC courses with maker elements is to instill multiliteracies in students. Thus, a key guiding principle for maker pedagogy is to pay attention to emerging literacies and promote awareness to new layers of understanding texts, tools, and technologies for the purposes of TPC. Students should be afforded with opportunities to utilize modes and modalities other than the conventional textual or verbal approaches to create meaning, shatter expectations, and deliver rhetorically sound messages through appropriate media. Thus, the second major tenet for Maker Pedagogy is **multimodality**.

The third guiding principle to maker pedagogy is focused on the lessons from constructionist and constructivist learning theories, where students are empowered by taking control of their learning topics and organizing their own learning process. Maker pedagogy should be about the core content any TPC courses aim to deliver as much as the problems students wish to address during their course of study. The third major tenet of Maker Pedagogy is **constructivist and constructionist learning**.

Lastly, students should be encouraged to make solutions together. One of the most important aspects of the maker culture is collaborative learning. By making together, students have the opportunity to learn from their peers, as well as to share their expertise with those who need them. This cultivates not just a sense of shared ownership but also empathy toward others. Maker pedagogy creates a space for this kind of shared inquiry to take place. Hence, the fourth and last major tenet of Maker Pedagogy is **collaboration**.

The four guiding principles presented here correlate with the four major tenets of maker pedagogy, as follows:

Maker mindset → Design thinking

Multiliteracies → Multimodality

Making tangible solutions → Constructivist and constructionist learning

Making together → Collaboration

7.1.2 The maker pedagogy framework

Building upon the aforementioned guiding principles, this section presents the full framework for a maker pedagogy. This framework aims to provide instructors with an understanding of the major tenets and elements of maker pedagogy, and ways to actualize them in TPC courses. Figure 39 is a visualized representation of the maker pedagogy framework.

Each of the four major tenets provides **two major maker elements** that inform the Maker Pedagogy and its actualization (i.e., how this pedagogy can be activated).

The two key maker elements to support the design thinking tenet in maker pedagogy are **iteration** and **action driven learning**. Aligned with recent arguments around the process of problem solving in TPC contexts, the maker pedagogy framework advocates for an iterative design process to TPC pedagogy. The implication for this perspective is two-fold. First, it requires TPC instructors and course designers to embrace the design thinking philosophy of prototyping, testing, and iterating their coursework as the course unfolds. This may sound horrendous to instructors who are accustomed to laying out all aspects of the course from the start and avoiding major changes after the course has begun. The maker element of **iteration** requires instructors to accept ambiguity of student learning needs and respond by making iterative changes along the way of the course.

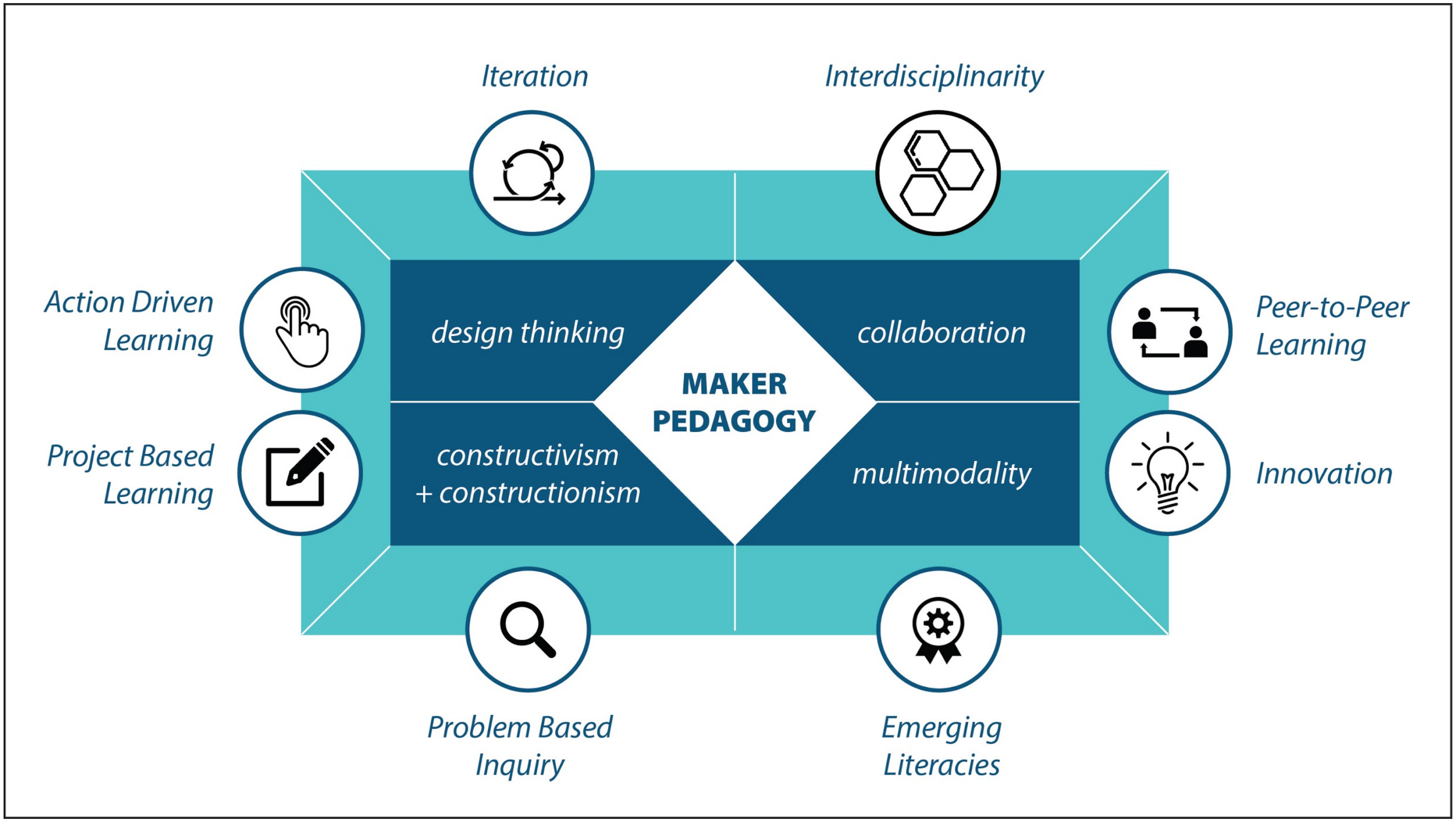

Figure 39. The maker pedagogy framework, visualized.

Second, **iteration** also means modifying our conventional student assessment methods (tests, papers, or presentations) to focus on continuous, incremental improvements in learning. Instead of being quizzed on their accumulated content knowledge, TPC students should be given projects where they could ideate and devise initial plans, prototype initial solutions, and test these solutions. Their performance shall be measured by their ability to showcase incremental improvements such as adding rhetorical elements to their iterative prototypes as to enhance their usability and rhetoricity. The key here is continuous development (like a curve) rather than development in stages (like stairs) (see Figure 40).

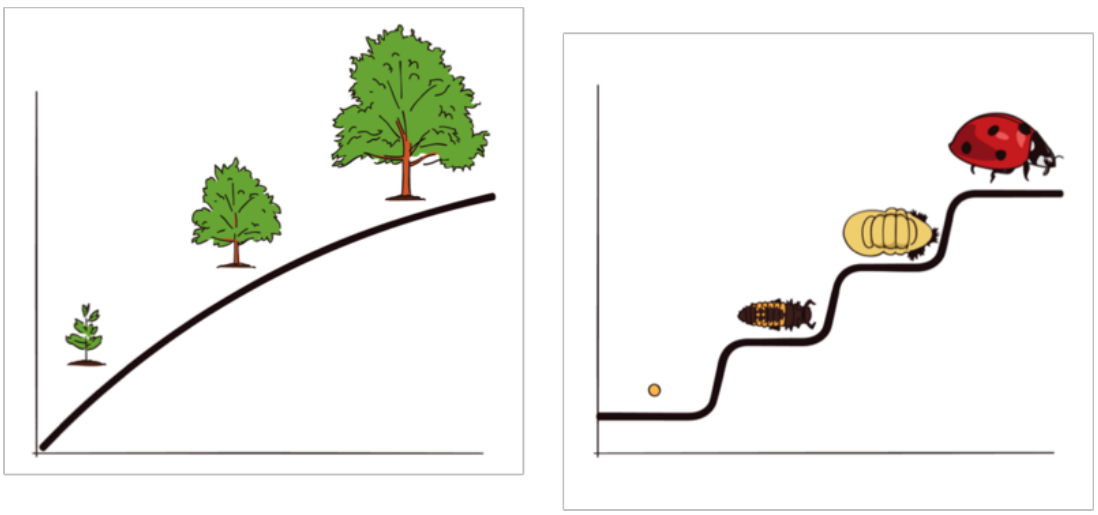

Figure 40. Continuous development (left) versus development in stages (right).

To support continuous development, TPC should be an **action driven learning** experience. The maker pedagogy framework motivates students to pursue actionable solutions, rather than those that are mere thought exercises. As with existing research on the benefits of active learning design, the maker pedagogy framework seeks to help students arrive at tangible, measurable results. In order to achieve those results, students should be given tasks that encourages their "doing" as much as their "thinking." While critical and rhetorical thinking should still serve as the foundation of any good TPC pedagogy, the maker pedagogy framework pushes it further by requiring students and teachers to put their thinking into action, ideas into creation, beliefs into advocacy.

Given the increasingly pressing exigence for cross-functional interactions and interdependence in higher education (Davidson, 2017), the second maker tenet of collaboration is supported by maker elements **interdisciplinarity** and **peer-to-peer learning**. TPC as a field is already interdisciplinary; it is made up of a myriad of professions such as information and user experience design, usability research, science communication, business communication, content management, project management, technical illustration, etc., across medical, legal, technological, scientific, scholarly, and other technical contexts. The maker pedagogy framework leverage such innate complex disciplinary identity by fostering interdisciplinary interactions—especially with those outside of our immediate or adjacent disciplines. One of the core values across academic making today is openness in access to facilities and projects. The maker pedagogy framework seeks to promote open spaces where students and instructors of different disciplinary backgrounds can interact and collaborate on projects. The goal of **interdisciplinarity** is to foster connections across disciplines to create a strong and productive network of resources.

Within the TPC classroom setting, the maker pedagogy framework emphasizes **peer-to-peer learning**, where students depend on one another to achieve the learning outcomes of the course. To do so, this framework favors collaborative projects that are sustained through the semester. Students work in cross-functional teams to support each other through cross pollination of knowledge and skills. They offer different perspectives to spur innovation and challenge conventional practices (i.e., "we have always done it that way"). Peer collaboration also levels the "playing field" for learning—students at any level or with any amount of content knowledge can participate in innovation and execution of ideas, which may increase overall engagement. The role of the instructor is to facilitate a learning atmosphere that encourages students to claim shared ownership of their project. The prototyped solutions should embody ideas from every student in the cross-functional teams.

The maker pedagogy is undergirded by constructivism and constructionism theories of learning. On the one hand, Piaget's constructivism is a theory of learning based on experience and observation. On the other, Papert's constructionism builds upon

Piaget's models to state that students learn best by making tangible objects through authentic learning experiences. Making embraces both learning theories and create a culture of **problem based inquiry** and **project based learning**. Students are coached to identify, define, and address specific problems. Within TPC curricula, students may focus on problems related to human experience in information technologies, communication processes, and professional practices. The goal is to create a learning experience where students could construct methodologies appropriate for understanding problems, collecting evidence, analyzing data, and designing solutions for testing. Modeling the emergent scholarship on design thinking in writing studies, the maker pedagogy framework highlights TPC issues as wicked problems that lack immediate or straightforward solutions. Helping students to see TPC issues as wicked problems encourage them to locate plausible solutions using developing knowledge they gain throughout the course.

The **project based learning** approach helps frame the TPC course experience as a holistic, and more importantly, tangible experience. Using semester-long projects like the Design Challenge let students focus on the specific tasks that can be managed by effect project management systems and skills, which are essential skills for future TPC workspaces. Students may also practice managing available resources, including tools, materials, time, and talent, in order to achieve their project goals. The outcome of this approach in the maker pedagogy framework is to create an authentic, real-life experience that allows students to learn by tinkering with tangible, material resources.

Certainly, the maker pedagogy framework would not be complete without the last of the four major tenets supporting the framework—multimodality. The maker elements manifesting multimodality are **emerging literacies** and **innovation**. Instructors adopting the maker pedagogy framework would encourage students to pay attention to emerging tools and resources that elevate, modify, or create new TPC genres. The goal is to help TPC students develop multiliteracies to address the increasingly complex problems they face. Through making, students experiment with new methods and tools, and mash existing literacies with emergent knowledge in the process. While current multimodality scholarship focuses on the medium and composing methodologies, there needs to be more productive conversations around emergence and innovativeness.

Combined with multimodality theories and methods, **innovation** is not just mere creativity but rather a guided exercise that utilizes all available means of creation to approach TPC goals or issues. This requires that students cultivate awareness in various modes and modalities—especially those that are nontraditional, verbal or textual—as well as material rhetorics. These awareness will be applied to their innovation and creative processes, which are ingrained into their TPC projects. Students should be motivated to pursue solutions that might seem radical at first but could potentially be realized through a systematic innovative process known as design thinking. For TPC, the maker pedagogy framework is a catalyst for innovation that promotes TPC as a leader especially in technological industries.

All eight maker elements described in this section serve as the main pillars for the maker pedagogy framework. These elements are not designed to be interpreted or acted upon in this following arrangement. Further, in the spirit of iterative design, I cannot limit the framework to these eight maker elements. In fact, I am confident there will be emerging elements following future deployments of this framework. Based on my study in this dissertation period, these eight elements represent the most essential constituents of the maker culture in TPC pedagogical settings. Table 15 provides summary descriptions of each major maker element included in the maker pedagogy framework.

Table 15.

Explications of major maker elements in the Maker Pedagogy framework.

Major Tenet	Maker Elements	Actualizations in TPC
Design thinking	Iteration	● TPC pedagogy as an iterative design process. ● Continuous, incremental improvements. ● Focus on adapting and responding to user needs with empathy.
	Action driven learning	● Bias toward actionable solutions. ● "Doing" as much as "thinking." ● Focus on achieving tangible, measurable results.
Collaboration	Interdisciplinarity	● TPC as an interdisciplinary field. ● Promote interdisciplinary interactions. ● Focus on building and fostering connections across disciplines.
	Peer-to-peer learning	● Instill horizontal instead of vertical learning. ● Co-ownership of solutions. ● Focus on sharing expertise.
Constructivism & Constructionism	Problem based inquiry	● Identify and define specific human experience problems. ● Devise appropriate methodologies for addressing identified problems.

		● Focus on tackling wicked design problems as TPC problems.
	Project based learning	● TPC curriculum to resolve around tangible projects. ● Use effective project management solutions. ● Focus on creating authentic experience.
Multimodality	Emerging literacies	● Pay attention to emerging tools and genres. ● Promote multiliteracies. ● Focus on emergent learning.
	Innovation	● TPC as a leader in innovation. ● Integrate creativity and innovativeness within pedagogical experiences. ● Focus on cultivating awareness in modes, modalities, and material rhetorics.

7.2.3 Assessment: Maker portfolios

Among the most popular questions maker educators receive is one that concerns the evaluative criteria for students who are learning through making. How do we know if a student has acquired TPC concepts or skills through their maker project? How might we assess collaborative work? How should students be held accountable in their learning? In this section, I provide global assessment heuristics to evaluate student learning through maker portfolios.

Indeed, as we integrate maker pedagogy into the TPC curriculum, we should determine how it aligns with field standards, and how we can assess making. Traditional, direct instruction focuses on *content* knowledge, while maker-centered learning orients around the student's *context*. It's a framework that allows students to actualize their own ideas. With any materials or equipment, maker education can be a tool or vehicle for learning that focuses on the how—the process and the application of problem solving, collaboration, and iterative design.

Current research is underway to understand the effects, effectiveness, learning outcomes, and related results of maker-centered pedagogy. As I advocate for the maker pedagogy framework as an educational approach to engage students while deepening their learning, I ask, what is worth measuring? What constitutes student learning in the maker context? These questions help me to consider the evaluation criteria for maker projects.

To push my assessment methods beyond my initial I-know-it-when-I-see-it brand of evaluating multimodal maker projects, I have turned to multimodal/multimedia assessment models that are transferable across compositional situations, such as those articulated in Warner (2007), DeWitt and Ball (2008), and Kuhn (2008). Following Cheryl Ball's (2012) recommendation, I consider Kuhn et al.'s (2010) assessment criteria to be particularly useful. Table 16 displays the parameters of multimodal assessment and descriptions of each parameter in Kuhn et al. (2010).

Table 16.

Institute for Multimedia Literacy honors thesis project parameters (Kuhn, V., Johnson, D.J., & Lopez, D., 2010).

Parameter	Description
Conceptual core	● The project's controlling idea must be apparent. ● The project must be productively aligned with one or more multimedia genres. ● The project must effectively engage with the primary issues of the subject area into which it is intervening.
Research component	● The project must display evidence of substantive research and thoughtful engagement with its subject matter. ● The project must use a variety of credible sources and cite them ● appropriately. ● The project ought to deploy more than one approach to an issue.
Form and content	● The project's structural or formal elements must serve the conceptual core. ● The project's design decisions must be deliberate, controlled, and defensible. ● The project's efficacy must be unencumbered by technical problems.
Creative realization	● The project must approach the subject in a creative or innovative manner. ● The project must use media and design principles effectively. ● The project must achieve significant goals that could not be realized on paper.

Kuhn et al.'s (2010) model is a great starting point to creating an assessment framework but it seems to be limited to individual projects and does not consider the invention process. To account for these compositional aspects—beyond the typically graded (or grade-able) areas of multimodal composition—I turn to another form of assessment that has been gaining popularity in writing studies, the portfolio model. Traditionally, "a writing portfolio is a collection of completed writing assignments" (Jones, 2011). However, the flexibility of a portfolio model allows its assessment framework be adapted to evaluate criteria in a multimodal assignment. Mary Kay Crouch and Sheryl Fountaine (1994) show that portfolios account for metacognitive work in students' composing process, thus allowing the instructor to include *process* as part of the evaluation:

> Students have to consider their composing processes and their development as writers [makers] over time. In this way, students become self-reflective about their writing; they can look longitudinally at their writing, begin to recognize change, and grow in their knowledge of who they are as writers. (Crouch & Fountaine, 1994, p. 308)

For this reason, a portfolio assessment framework, combined with multimodal evaluation emphases outlined in the various sources I reviewed above, can make an appropriate assessment framework for maker pedagogy projects. I call this assessment framework *maker portfolios*. Maker portfolios can showcase a student's abilities, interests, voice, and thinking. Maker portfolios are made up of the following:

- Descriptions of student makers (who they are)
- Overview of project and stakeholders (scope, rationale, audience)
- Project statement and definitions (technical definitions/descriptions, key terms)
- Methods (how students collect and analyze data to help them create solutions)
- Proposed solutions and prototypes (including tangible prototypes, instructions for using the prototypes, and descriptions of the design process)

- Testing, evaluations, and results (preferably involving actual users and usability studies)
- Discussions and conclusion (next steps, iterations, etc.)

Given the collaborative nature of maker projects, I have created a set of assessment heuristics that aim to assess students' portfolios. I call these evaluative measures *heuristics* because they are not meant to be hard-and-fast criteria for assessing student performance. Students' maker projects will prove to be too complex for standardized evaluation. Thus, I take a global approach to assess student learning based on their project ideas, how well they communicate those ideas, and the overall presentation of the project. Importantly, these maker portfolios are evaluated as a collaborative effort. Table 17 contains the descriptive heuristics for each letter grade level (grades A through F).

Table 17.

Assessment heuristics for collaborative maker portfolios.

A	Excellent	● The project extends and explores ideas and concepts from the course materials and discussion. ● The makers take ownership and responsibility for coming up with topics, establishing a focus, developing the idea, and seeing it through to the final finished quality product. ● The project deals with complex ideas and issues. Ideas are thoughtfully developed with carefully chosen support and detail. This expression of ideas is fluent, thoughtful, and effective. ● The makers take risks, experimenting with a variety of formats. ● The makers demonstrate a sophistication of language usage. Vocabulary is appropriate to the tone and topic of discussion. Terminology is discussed in a meaningful context. The makers' voices come through. ● The makers are confident, insightful, and perceptive. The project demonstrates confidence in idea construction. ● The writing/presentation of the project is error free. The makers' memos (self-assessment) demonstrate a growing self-awareness and ownership in improving knowledge or skill sets. ● The makers set high standards and strives to meet them.

B	Above satisfactory	● Topics are related to the ideas and issues that arise from the course materials and discussions. Understanding is evident. ● The makers consider their impact on the reader. ● The project has met all deadlines. ● Peer input is valued during the process of the making. The makers uses feedback from peers to revise. The makers are committed to producing a polished final product. ● A clear focus is established and thoughtful ideas are supported with appropriate evidence. The overall project is organized so that it has an impact on the reader. ● Vocabulary is clear and appropriate. Language used is straightforward, clear, and fluent. The project demonstrates competence in control of idea construction. Minor and minimal errors. ● The makers' memos carefully consider what has been accomplished in the writing as well as dealing with specifics of the project.
C	Satisfactory	● Most deadlines have been met. All project requirements have been met (including revisions when asked to do so). ● Topics are related to the ideas and issues that arise from the course materials and discussions. ● Ideas are dealt with simply but clearly and supported by/with some kind of evidence.

		● The makers are focused and the project provides a general direction for the reader, but discussion of idea may be general or predictable. It may lack the specific detail needed to support ideas. ● Vocabulary is imprecise and/or inappropriate. The writing may be straightforward but limited to simple structures. The makers demonstrate control of the basics of idea construction. There may be occasional errors, but the communication of ideas is clear. The makers are aware of their purpose and audience. ● The makers' memos are beginning to deal with specifics of the project.
D	Below satisfactory	● Deadlines have been missed/portfolio is incomplete. ● Topics are not related to ideas and issues from course materials and discussions in the classroom. ● The makers may be confused or lack the background to deal with the subject chosen. The project lacks a focus and/or is unable to develop an idea. ● The makers may be unable to use simple organization to organize ideas. The makers lacks control of conventions and language usage. ● Overall, the project is not communicated clearly and/or effectively.
F	Incomplete or did not meet requirements	● The makers have not completed any assignments or have made no effort in the project submitted.

Note that the assessment heuristics pay closer attention to the global performance of the students (makers) as evaluated through their overall project outcome, rather than individual contribution. The maker portfolios are likely to take a digital presentation form, such as a website or cloud based content management systems like Google Drive. Certainly, should the course requires specific genres to be highlighted and evaluated, they can be assigned specific points for grading purposes. For instance, in a general technical and professional writing course at the University of Minnesota, genres like the technical proposal, analytical report, and instruction sets are deemed “required” learning outcomes (see Chapter 6 for details). In other courses, such as business writing and international professional communication, the business proposal and cultural reports might be emphasized. Nevertheless, these genres can be integrated with the maker portfolio and given separate points or grade systems, and should still be assessed holistically within the maker portfolio.

Innate to portfolio creation is the process of self-reflecting, curating what's most appropriate for the intended audience and articulating the evolution of learning and making. To assess individual learning, I recommend strategic personal reflections through maker’s memos. The maker’s memos are inspired by Shipka’s (2011) assessment model for multimodal composition, which she terms *statements of goals and choices*, or SOGC. These memos document individuals’ choices of media, how their decisions are informed by course materials, and what argument does their made artifacts make. Instructors may elect to assign separate grades for individual contributions in the collaborative maker projects using these maker’s memos. These memos should be submitted as part of the collaborative maker portfolio so students see them as an integral part of the project rather than a separate entity.

Since the above heuristic was developed after my case study of a maker-based WRIT 3562W, needless to say it wasn’t employed as the assessment direction for the course. However, as I continued to teach with the maker pedagogy framework in the following two semesters (Spring 2018 and Summer 2018), I have used the above assessment strategies to evaluate student maker projects. I shared such assessment experiences in conferences like the Association for Computer Machinery’s Special

Interest Group in Design of Communication in August 2018 and Association of Business Communication in October 2018.

In the next section, I will discuss the implications of the Maker Pedagogy framework and direction for TPC, rhetoric, and writing studies.

7.2 Implications for rhetoric and scientific and technical communication

In their Call for Proposals to a special collection of TPC foundational knowledge, Lisa Meloncon and Joanna Schreiber (2018) argue that our field needs to address the issue with the "increasing fragmentation of technical and professional communication where we seem to be fracturing into a little groups that become echo chambers to only those ideas of the group" (n.p.). I see a similar phenomenon happening within the academy at large; we are increasingly broken into smaller sub-disciplines and specialties that pull us away from another rather than uniting us to address complex problems together. One of the most noticeable differentiations is the STEM (Science, Technology, Engineering, & Math) distinction. As I have shown in Chapter 2, the Maker Movement seems to be able to do some work of reconciliation between STEM and non-STEM fields by bringing people with such different backgrounds to the same space and share the same project.

My makerspace observations and case study of a pedagogical deployment of a maker-based TPC course have given me a rewarding experience in seeing the overlaps between the STEM fields and the arts and humanities. While many have argued that such distinction is artificial and unwarranted, we can see quite clearly through the ways our academies like universities and learning societies are organized that this distinction still influence how we work—separate in our respective siloes. In many ways, this dissertation project has allowed me to dip toes in two of these worlds, and help make connections through one thing both worlds share—pedagogy. Whether in STEM programs or humanities branches such as writing studies (including rhetoric and composition; technical, scientific, and professional communication), we know that every discipline values pedagogy that responds to the changing needs of the learners. The

Maker Movement and its influence across multiple disciplines have created a unique opportunity to bridge STEM and the humanities, and to collaborate on pedagogical initiatives that attend to teaching and learning needs.

Introspectively, I have learned some connections between this work and the field of rhetoric and scientific and technical communication. While there are growing literature sources that make justifications for “making” in composition and creative writing studies (see Breaux, 2017 and Craig, 2014), there is none directly addressing its benefits for technical and professional communication. This seems surprising to me because one could easily see the relationships between learning to make, learning to collaborate with designers and engineers, and learning to communicate a designed solution to specific and general audiences with the kind of work we do in technical and professional communication. Having completed this dissertation research, I am reassured of these relationships because students who participated in the course understudied have reportedly developed technical writing and communication skills through making.

In terms of theoretical advancement for our field, I offer the following arguments underscored by the experience and findings from this project.

7.2.1 Reinventing invention: Collaboration and prototyping rhetoric

Rhetoricians have spent much of the last century updating the rhetorical canons for the 21st century (e.g., Brooke, 2009). Research in the last part of the twentieth century on materiality (Haas, 1996), embodiment (Lee, 2004; Rickert, 2013), and rapidly developing technologies (e.g., McCorkle, 2012) has driven scholars to look more closely at invention in particular. Peter Simonson (2014) in “Reinventing Invention, Again,” proposes an eleven-part framework of “inventional media” to account for a variety of social, political, economic, embodied, and material forces (among others) in invention. Room remains, however, in rhetorical studies, for further investigation of the embodied, material nature of invention, especially as the rapid evolution of composing technologies continues. My project contributes to one of such investigations.

By the way of studying how makers invent in a technologically enhanced workshop such as the makerspace, I have learned that rhetorical invention could be theorized as a collaborative effort. While traditional invention theories focus on how the author, as a singular entity, conceive topoi and forge audience interest, research in collaboration suggests that inventive effort can be a collaborative experience. For instance, the users of makerspaces in this study have all responded with previous experience of collaborative problem solving. In those experiences, users have explained how they relied on one another's expertise and prior knowledge to define the problem at hand and ideate possible solutions. Many a time, even when the user did not intend for collaboration, the makerspace experience was collaborative by default due to its setup and operative model. Users were encouraged to interact with volunteers in the makerspaces—much like tutors in a writing center—and share with them their project. They might work on the project on their own; but as all of my interviewees from Part 1 of this study have revealed, they tended to "nudge" other users in the makerspace whether they were looking for help or if they saw something could have been done differently by another user.

If we see invention as a collaborative endeavor, we might open new possibilities for shared rhetorical practice and knowledge. While invention, for most rhetoricians, refers to the capability to create effective communication and the instruction of this capacity, an expansion to collaborative invention signals the need to include new insights on interpersonal interactions that would help to achieve the aforementioned capability and instruction.

Second, as is innate to the culture of making, the outcome of a maker project may not always be the final, "shippable" (as software engineers would call it) product. This does not mean the outcome isn't worth examination or critique. While we—writing teachers and professional communicators alike—tend to focus primarily on well-formed, complete rhetoric in professional or scholarly communication, the maker culture challenges us to see arguments from incomplete, in-progress prototypes. When addressing the Design Challenge in my course, students worked to ideate solutions and created prototypes of their most viable solutions as a way of making arguments for the recommended solution. Although the prototypes were partial and thus not fully functional, they still added much persuasive power to the presentation of solution as a demonstrative element of the rhetorical process.

This means that our understanding of *techne* may be updated with incomplete crafts that are meant for similar persuasive purposes as complete arguments. Todd Mei (2015) argues that *techne* can be broadly defined as "the type of knowledge involved in crafting, artificing, or the application of a skill" (p. 270). Yet, as R. A. Hodgkin (1990) argues in "*Techne*, Technology, and Inventiveness," "A true *techne* will often grow from these and yet will come to embrace much more: standards, values and inspiration from the past; adventure and disciplined initiatives for the future" (p. 208). Indeed, *techne* should not be constrained by existing convention but instead has the capacity to embrace an adventure that may reinvigorate it to become a catalyst for innovation through work-in-progress. When invention "grows" beyond our expectations for perfection or perfected product, it makes room for innovative ideas—pre-formed or otherwise—and allows for ambiguity and fluxivity in the their growth. The rejuvenated concept of *techne* adds to what most rhetoricians already knew as the continuously developing inventional toolkit—topos (topic), genre (type), kairos (time), stasis (points of issue), enthymeme (logic), etc. Unlike others in the toolkit, the notion of imperfection warrants critique and revision. This lets rhetors, including makers and students, emulate a culture of iterative design of communication based on audience feedback. For technical writing and communication, this is a considerably critical skill since much of the work of technical communicators rely on user experience. While iterative design is not a new topic for TPC, it needs to be discussed more consistently beyond TPC—within writing studies writ large.

7.2.2 Expanding multimodality: Multimodal genres and possibilities

In "Polymorphous Perversity in Texts," Johndan Johnson-Eilola (2012) argues that multimodal theories can be expanded by seeing multimodal texts as multidimensional texts—beyond just signs and symbols. He challenges us to consider the ways we take pleasure in texts by interacting with them through fragmentation, unmaking, and remaking. Similarly, David Blakesley (2018), in "Composing the Un/Real Future," shows that the invention of new "writing" media such as virtual and augmented-reality tools expands "the genres, platforms, spaces, channels, and containers for the work of composition" in a way that challenges our preconceived understanding of writing/communicative forms and features. Blakesley further argues,

> "Making"—part of Aristotle's triad of *knowing, doing*, and *making*—has always been closely related to the acts of composition we teach our students and practice ourselves. Until a few decades ago, the tools for making these complex forms have been limited primarily to text because of the relative inaccessibility of the machines and interfaces that would democratize the production and distribution of multimedia. (Blakesley, 2018, p. 10)

Blakesley and Johnson-Eilola demonstrate in their arguments that textual practices illuminate the "made-ness" of writing, making it more explicit the influence of modes and modality in our composing worlds—technical, social, personal, professional, etc. Further, this made-ness also turns our attention from the material to the ephemeral elements of our communicative practices, revealing new texture or layers of invention. We may enter this discussion through the lens of multimodality.

The findings from this project demonstrates that, in addition to semiotic approaches (i.e., Kress, 2000, 2010; Kress & Bezemer, 2008) to multimodal invention, it is necessary to address the affective, embodied, lived experience of multimodality in more explicit ways. First, my ethnographic observation of three makerspaces has led me to understand how multimodal rhetoric can focus on the embodied experience of modalities. Through the users' interactions with objects and bodies in a makerspace, we may see how the body—corporeal, representational, gendered, experiential, and physical—interacts with the rest of the constituents in the multimodal invention process, such as tools, resources, media practices, physical spaces, and social environments. Along this theoretical direction, I argue for a greater complexity in the conceptions and uses of modalities, particularly when they are mapped onto the space-place-body dimension.

The gendered experience of making is an emerging focus in makerspace research. I observe in at least two existing dissertations that gender differences are studied as a factor for the quality of making and learning experiences in makerspaces (Shivers-McNair 2017, West-Puckett, 2017). Central to my study, however, is the intersection of the physical and material experiences of making and their impact on collaboration and learning. Most students did not specify—or call attention to–-the effect of the makerspace design on their experience of making in the space. Yet, through my observation, I have noticed the influence of space/place in these makers' invention process.

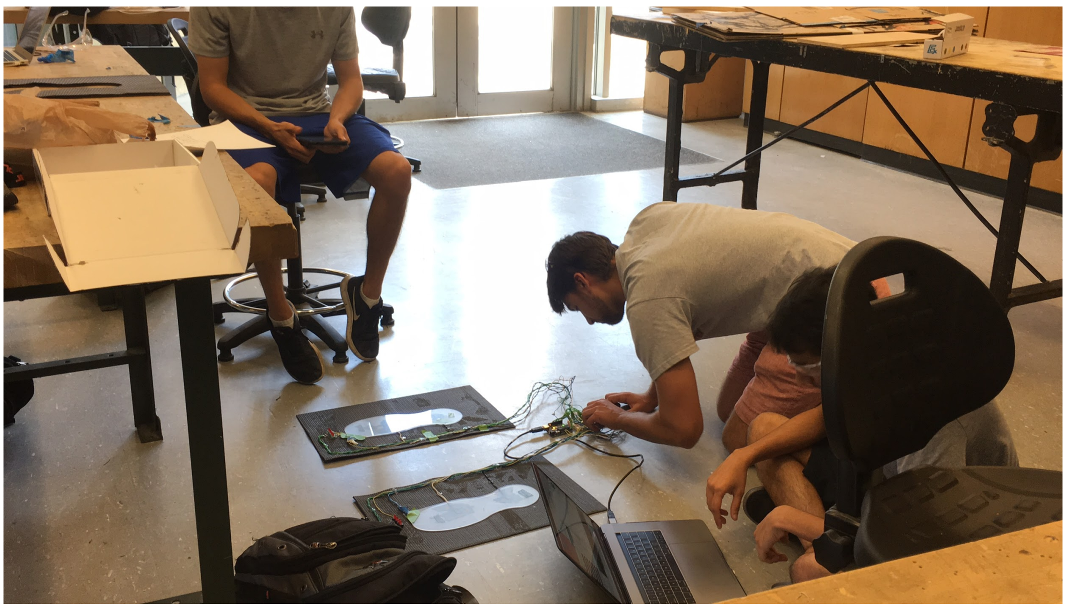

Figure 41. A student team working on a project at the Invention Studio lounge area.

In many instances, students adjusted their bodies and work processes to the makerspace. In Figure 41, a team of students is shown working on the floor and around the workbenches in the lounge area of the Invention Studio at GA Tech. While working on their project, these students shifted and maneuvered their bodies and project materials to suit the given workspace. Although it may be invisible from the prototype or final product, their bodies have become a part of the production. The modality of their work includes a corporeal integration that is not often discussed or critiqued in our review of communicative products and processes.

Another example of embodied modality can be seen in the distribution/division of labor in makerspaces. Figure 42 shows a roster in one of the common rooms in the Invention Studio displaying names of those who were scheduled to be Prototype Masters providing oversight in respective work rooms—wood room, electrolounge, 3D printer room, metal room, and waterjet/laser room—during specific hours. This is an instance for which bodies intersect with place and time to support inventive experiences. One could turn to Activity Theory for plausible explanation for such phenomenon. Activity Theory dictates that invention—as an activity-–should be seen as a systemic and socially situated occurrence that accounts for the environment, people, culture, the role of the artifact, motivations, and the complexity of real-life activity. This observation, when combined with multimodality frameworks, may sparkle new, expanded understanding of the importance of the corporeal experience in communicative practices that span beyond just the material reality.

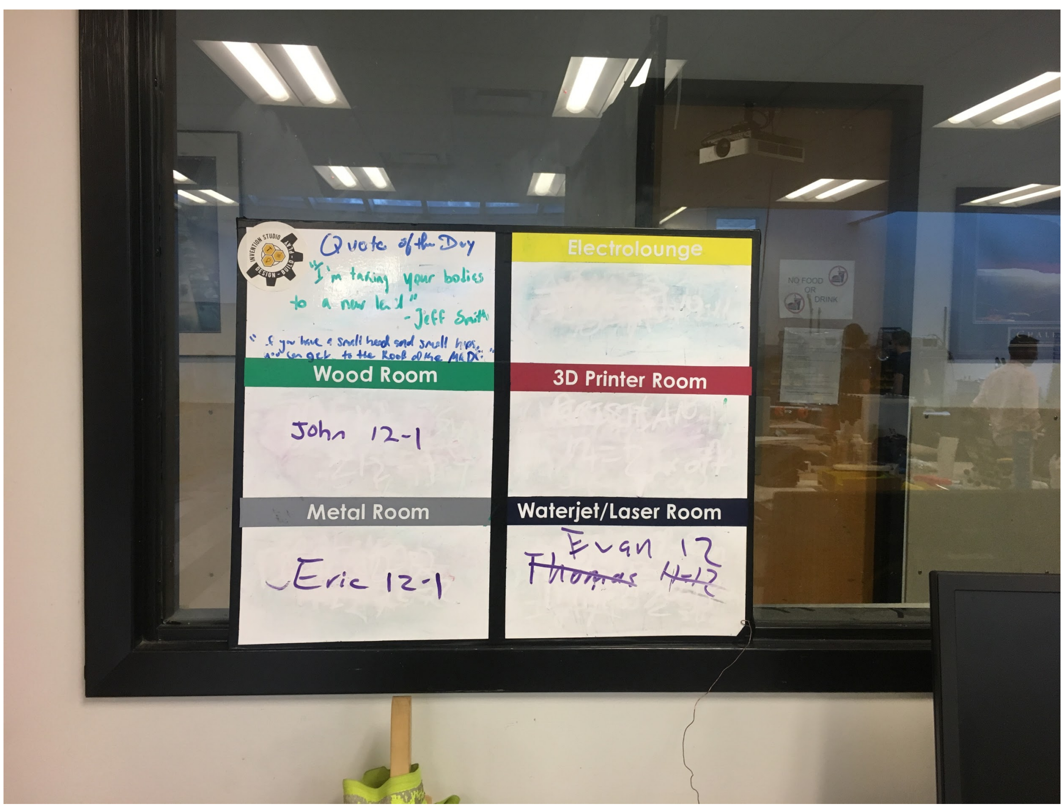

Figure 42. A duty roster for Prototype Masters at the Invention Studio.

Lastly, I also note a phenomenon of genre mashing in making that is worth further discussion. When observing the kind of projects students were working on in the three makerspaces, I have come to realize that a lot of the inventions were indeed innovative and boundary-pushing. In other words, students were creating things that have yet to exist in the world, prototyping models that could be used for testing and for further iterations. In the example shown in Figure 43 and 44, two students at the Invention Studio were working at conjoined stroller that is wired for automatic folding. I note this as a genre mashing moment when students work to combine existing stabilized genre with new features.

Figure 43. Two makers working on a conjoined strollers in the Invention Studio.

Figure 44. Close-up of a student working on a conjoined stroller in the Invention Studio.

In my own pedagogical deployment in WRIT 3562W, my students also came up with ideas that mashed conventional genres with new configurations that improved the existing genre. An example is found in the NextJEN team's proposed solution for improving the campus dining experience. In place of the current entry-based system, this student team created a point-based system for meals calculation across campus dining halls. The students prototyped a "PointPost" scanner (see Figure 45 and 46) to collect data on campus diners' meal selection.

Figure 45. A “PointPost” scanner.

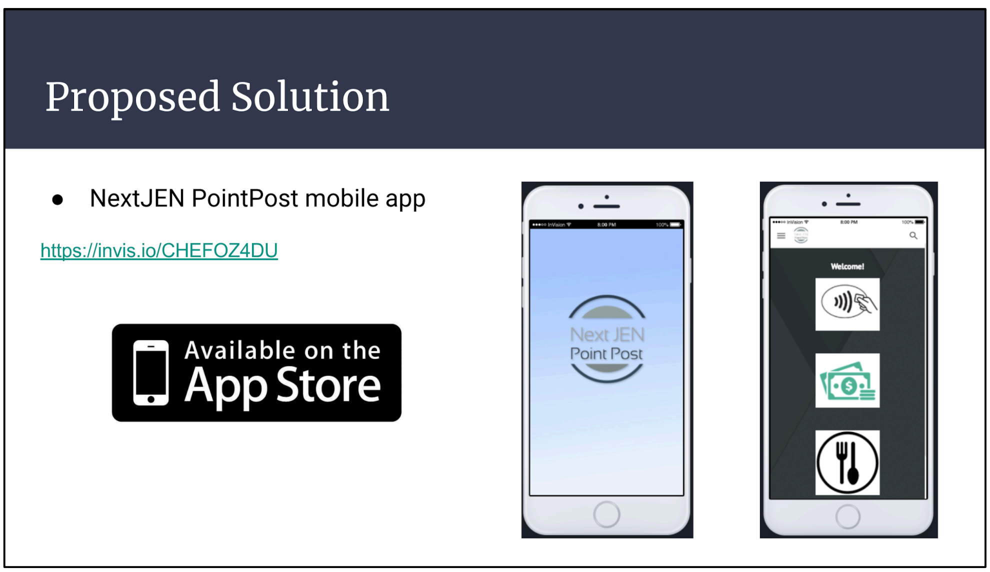

Figure 46. A corresponding mobile app mock-up for the “PointPost” scanner.

This example shows how a maker-driven invention process pushes the envelope of multimodality to embrace moments of genre mashing. In the Invention Studio example, what was once analog is now electrified for ease of use. Along the same line, my student team has shown how we might leverage big data to help students save money and campus dining create better services for students. The combination of the analog and the digital, and its contextual application, are what scholars of multimodality need to continually investigate and tinker with in their future studies.

7.2.3 Reimagining learning spaces: Interdisciplinary, collaborative, active learning

Makerspaces are redefining learning environments. Researchers of makerspaces as active learning environments argue that makerspaces offer pedagogical models that engage learners in active thinking and hands-on learning while promoting creativity, problem solving, and collaboration skills (Pejcinovic, 2017; Trust, Maloy, & Edwards, 2018). Current active learning scholarship, however, seems to focus on individual learning (Center for Educational Innovation, UMN, n.d.). "The spaces, places, and infrastructures of writing [and learning] matter," Jim Purdy and Danielle DeVoss (2017) contend in their recent inventive collection, *Making Space: Writing Instruction, Infrastructure, and Multiliteracies*. Given the democratization of self-publishing and "self-making" technologies, writing studies must pay attention to the processes, practices, and challenges of infrastructural and technological needs within specific learning contexts.

Figure 47. Web masthead image from UMN Office of Classroom Management showing an "active learning classroom" with technology-enhanced student tables.

From my observation at three academic makerspaces, I have noticed a shift from individual problem solving to shared, collaborative inquiry due to these studio spaces that are designed to foster peer-to-peer learning. Students are encouraged to ask questions while they are working on their projects. These questions are sometimes about ways to use a tool, or methods for measuring something. Sometimes, students simply ask one another for opinions on their work-in-progress. They seek validation from their peers, rather than the instructor alone, as they iterate their design. This phenomenon is appropriate for promoting student self-awareness as learners as well as partners to those who are working on their own projects. During my visits, it was eye-opening for me to see how generous students were in offering their perspectives and guidance to those around them even if they were not working on the same project. This notion of shared learning adds a new dimension to active learning that can cultivate learners' empathy, willingness to share, and capacity for motivating others.

Besides, as is shown through the student projects in WRIT 3562W and the findings from my three makerspace visitations, there is certainly a bias toward hands-on problem solving in makerspaces. Students are pursuing tangible solutions for problems they identified as critical during the course of their study. Informed by design thinking methodologies and driven by maker ideologies, makerspaces invite students to build and create material solutions to address problems they deem important. During my pedagogical deployment, students were working with wireframing software applications and 3D printers to design and prototype their ideas. While it may seem surprising to students at first that they would be creating something they could touch and feel by the end of the course, that became their motivation to refining and detailing the solution they propose to address the wicked problems they identified in the beginning of the Design Challenge.

Lastly, I observe an interdisciplinary effort in the maker approach to solving problems that are ambiguous or hard to define. Across the three makerspaces I studied, they all welcomed users who come from different majors, disciplines, and interests. The makerspace is a neutral learning space like the library where students don't feel they are forced to identify with a certain disciplinary identity. When applied to pedagogical designs, making and makerspaces foster an interdisciplinary collaborative approach to active learning that expands students' experience in problem solving. Given the openness to any discipline or background, students naturally meet those who have different skill sets and knowledge than theirs, thus allowing them to work together to tackle wicked problems that are difficult to resolve by any one disciplinary expertise alone. Students also learn to be generous in sharing their own knowledge with those who do not understand their field's language, concepts, and practices. Finally, students learn to embrace differences and accept other students' perspectives by understanding their motivations, design purposes, and methods through learning of their disciplinary language. This kind of interdisciplinary, collaborative active learning gives students an edge when entering a diverse workforce as it provides students with prior experiences in practicing empathy, problem-focused inquiry, and openness to professional differences.

7.3 Chapter summary

Making for learning in a TPC curriculum should be an authentic experience; it should be a systematic structure so instructors and students could see the values and goals of making. This chapter has explicated some implications of a maker approach to TPC pedagogy, including implications for rhetoric, multimodality, and learning spaces design. I have outlined a framework for maker pedagogy by discussing the key maker elements and the ways they can be actualized in TPC pedagogy. This chapter ends with an assessment model for the maker pedagogy framework using maker portfolio and maker's memos. In the next and final chapter, I conclude this dissertation project with discussions of the study's limitations, directions for continued research, and visions for the future of maker pedagogy.

CHAPTER 8
Conclusion

This final chapter provides a summary to this dissertation project and discusses the limitations to the design of this study. I also provide some future research directions pertaining to maker pedagogy and TPC instruction. Lastly, I offer a possible direction toward socially just and pedagogically meaningful making in the near future of higher education.

8.1 Summary of dissertation

This dissertation investigates how maker practices can influence TPC pedagogy and enrich student experience. My central research question is informed by ongoing scholarship around design thinking, multimodality, collaborative learning, constructivism, and constructionism that help me to focus on the affordances of "making" in TPC pedagogy. I ask: **How do students compose and create multimodal solutions to address complex problems via technology-enhanced maker practices informed by design thinking?** The results I arrived at the end of this project reveal that

1. Students compose together,
2. Students create multimodal solutions with both digital and physical objects,
3. Students create multimodal solutions that are prototypes, not finished products,
4. Students address complex problems by collaborating across disciplines, and
5. Students innovate solutions that are not traditional in disciplinary sense, through design thinking methodology.

I began my investigation by visiting three academic makerspaces in the U.S., namely the Anderson Labs at the University of Minnesota, Invention Studio at Georgia Tech, and Think[box] at Case Western Reserve University. Through the site observations, I noted similarities and differences across the makerspaces in terms of their setup, operations, student involvement, and maker experiences. I have learned that students utilize these makerspaces for both personal and class-related projects. They revealed that collaborative learning is a key factor for their positive experience in the makerspaces. Besides the appreciate for their access to rapid prototyping facilities, students are motivated by others in the makerspaces as they assist one another to achieve their goals.

Using the findings from my makerspace observations, I designed and deployed a TPC course—WRIT 3562W Technical and Professional Writing—in the Fall 2017 semester at the University of Minnesota. I aimed to study how we might teach TPC through a maker-based course design by observing student learning, their projects, and their reactions to a course that had revolved around a semester-long design challenge. The major themes I derived from student projects, surveys, interviews, student self-assessments, student rating of teaching, and my own reflections from the instructor's standpoint are 1) "making" as a mindset, 2) making challenges TPC pedagogical conventions, and 3) making fosters new literacies.

Combining the findings from my site observations and pedagogical case study of WRIT 3562W, I have created a maker pedagogy framework that integrates key maker tenets and their respective maker elements to activate an authentic, collaborative, and multimodal learning experience for TPC students and instructors. I have also included an assessment model that utilizes a maker portfolio method and student self-reflection to help instructors evaluate student learning within the maker pedagogy framework.

8.2 Key contributions

As a scholarly endeavor, this project hopes to contribute to the intellectual domains I draw from: multimodality, design thinking, collaborative learning, and constructivism and constructionism in TPC. Though this work is by no means pioneering in its insistence on the prospects of these domains in TPC studies; however, it makes an explicit effort to create connections between these domains and maker practices.

8.2.1 Multimodality

My dissertation has sought to demonstrate a way to expand current conceptualizations and actualizations of multimodal composing, particularly in TPC studies. Emerging scholarship in multimodality has urged instructors to integrate modes and modalities beyond print and screen based representations or mediations of ideas. While Selfe (2009) has recommended a sonic emphasis, and Shipka (2011) has suggested involving dance and other mundane materials like food, clothing and shoes to amplify messages, their scholarship was published before the popularization of the Maker Movement. The Maker Movement has democratized ideation and production technologies by opening access to prototyping tools to non-experts. Doing so has given students and young makers the power to be producers rather than just consumers of designed products. Some of us may recognize this democratization in the desktop revolution, where non-expert users gained control to self-publishing tools and that led to the growth of user-generated contents. This dissertation works to capture a similar opportune moment of open-access making in the academy and argues that multimodality theory could benefit from an expansion by including new genres, literacies, and multimodal practices.

8.2.2 Design thinking

Popularized in industry by the Stanford d.school, design thinking is more than a professional buzz term. Given TPC's close connection to industrial trends, many TPC courses around U.S. institutions have attempted various versions of design thinking exercises to boost student innovation and awareness of human-centered design. A forthcoming special issue of the *Journal of Business and Technical Communication* (co-edited by Rebecca Pope-Ruark, Joe Moses, Trey Connor, and Jason Tham, 2017) has been dedicated to investigating the validity of design thinking for TPC pedagogy and showcase some forward-thinking models. Evidently, the TPC pedagogical community is becoming interested in the design thinking approach but lacking confidence in applying the methodology in their courses. This dissertation has demonstrated one way to integrate design thinking with conventional TPC genres—such as technical description, instruction set, usability test, proposal, and analytical report—in a semester-long collaborative project called the Design Challenge.

8.2.3 Collaborative learning

Since the early advocacy of process theory in the late 70s, collaborative learning has been a topic of interest to writing studies scholars. From large international conventions to small local conferences, sessions are dedicated to discovering new and effective ways to cultivate collaboration among students. At a time when interdisciplinarity is highly regarded as a way to address complex problems, create new methods, and develop critical thinking, collaborative learning has earned a place in most writing classrooms. Peer reviews and team projects are instances of collaborative learning. While there are established models to facilitate collaborative learning, instructors are on the lookout for new approaches to increase student engagement and improve student attitude toward team based exercises. As revealed in the findings of this dissertation, students appreciated a "maker" approach to a collaborative project that enabled them to tackle larger problems they would not have taken upon themselves individually. This project has demonstrated a new possibility of collaborative learning that leverages design thinking values, especially empathy and prototyping, which heighten students' metacognition during team processes.

8.2.4 Constructivism and constructionism in TPC pedagogy

Writing studies is founded in the tradition of rhetoric; its adjacent fields, literacy education and postsecondary instruction, are rooted in learning theories that are built from cognitive, behavioral, and social psychology. Although scholars from our field may see the suitability of learning theories in writing pedagogy, formal investigations and integration of these theories in writing pedagogy are dated. Through the present project, I have attempted to revive interest in the usefulness of two learning theories—namely constructivism and constructionism—in writing studies/TPC pedagogy. I find that these formal learning theories, combined with rhetorical perspectives, can serve as a valuable foundation for building and designing TPC courses. Constructivism reminds us that knowledge is socially constructed and experientially enacted, while constructionism advocates for tangible, authentic learning exercises to immerse students in realistic problem solving. Through the Design Challenge, students in this study have turned out to meet—some even exceed—the learning outcomes of a TPC course. This dissertation demonstrates, albeit at an exploratory level, the possibility of integrating formal learning theories in our writing pedagogy as a foundation for effective learning design.

8.3 Limitations and future research directions

This dissertation project is limited by time and the correspondents with whom I interacted and collected data. As indicated in the methods chapter, I have chosen the three academic makerspaces to visit and observe based on their availability and representativeness of the academic making culture. While they all have common facilities (tools, materials, resources), each of the three makerspaces has unique characteristics that provide different experience to their makers. Together they enrich my understanding of makerspaces in terms of how they operate, organize their staff and volunteers, and engage students. I relied on a convenience sample of respondents in these makerspaces by approaching them as I meet them across the three sites. To achieve balance, I focused on two main students at each makerspace to gather their stories and maker experience. This small sample size was sufficient for the purpose of this dissertation but future studies would benefit from a larger set of respondents. I recommend reaching out to makerspace directors or student managers prior to site visits to gauge interests from local respondents—students, community users, faculty members, directors, and even university administrators.

Future studies may also consider extending the duration of site observations. Given budgetary constraints and limited travel arrangements, I was only able to spend two to three days at the Invention Studio and Think[box]; my "home field advantage" has allowed me to spend more time at the Anderson Labs but overall the duration of observation across these three makerspaces could benefit from a longer, more immersive ethnographic study. Spending more time on-site may allow researchers to build stronger rapport with users of the makerspaces and thus lead to deeper, more engaged responses. Researchers may consider participating in the makerspace itself so to get better insights on the routine operations and interactions with users. Researchers may also speak with faculty members who are already integrating their courses and research projects with makerspaces so to get better insights on how these faculty members design their courses for students.

As for the pedagogical case study, the present project has focused on a single course deployment. The sample size is thus limited to the students enrolled in the course. Future studies may consider cross-sectional and longitudinal designs to examine more dimensions of the maker pedagogy framework in TPC instruction. In a cross-sectional study, researchers may test and validate the impact of maker elements in the maker pedagogy framework by juxtaposing them against multiple variables, including student gender/sex, majors, experience, technical and technological literacy, etc. I also recognize the potential conflict that may be caused by my duo role as an instructor of record as well as a researcher in the classroom. Students may not always feel they have a choice about their participation in the study; for example, they might have obliged simply out of fear that their grades could be affected. Such research design—where one's students are the subject of study—is an ongoing challenge for teacher-researchers. I acknowledge such challenge as a limitation to this study.

To address the aforementioned issues, researchers may use a longitudinal design to study student learning over time. Learning over time is one of the most crucial yet difficult aspects to study in makerspace research. Especially in higher education settings, where instructors lack sustained relationships with students (more than one semester), student development over their college career with regards to maker values are hard to measure or stipulate. Future studies may consider both horizontal and vertical integration of maker pedagogy to identify its impact on student learning. A horizontal integration might look like this: Each major course in the TPC sequence includes a maker project where students practice design thinking, prototyping, and collaborative problem solving. A student pursuing a TPC major would compose a maker portfolio as his or her capstone project. For vertical integration, a "maker" course can be created and housed within a college whereby every student at the university will take (much like the traditional first-year writing course requirement).

8.4 The future of academic making: To be socially just and pedagogically meaningful

At the end of *Toward a Composition Made Whole*, Shipka (2011) emphasizes that multimodal composition does not aim to downplay the presence of the written word. She states,

> Rather, a composition made whole encourages us to attend to *still more* possibilities and potentials for making meaning, and with this, to explore how an ever-changing communicative landscape continually provides us with opportunities to rethink and reexamine the highly distributed, multimodal aspects of all communicative practice. (Shipka, 2011, p. 148)

I concur with Shipka as I wrap up this work with a look into the future of academic making in TPC pedagogy and beyond. Shipka has laid a productive foundation for multimodal approaches to composition, which includes TPC, but I add that a defined methodology such as design thinking and collaborative learning—as they are built into the maker pedagogy framework—would help instructors to take the next steps in integrating purposeful making in their own courses. This framework brings collaborative problem solving to the forefront of TPC pedagogy while leveraging the multimodal aspects of TPC genres and practices.

As I continue to investigate the impact of such a framework for learning, I am drawn to the social, political, and ethical dimensions of academic making. As most pedagogues are aware, the landscape for learning—including its technology—is always shifting and continually re-mediated. We need to focus on the appropriation of valued practices, be it in TPC pedagogy or others, so we may achieve ethically justified ends. I highlight this need for ethical consideration in academic making because, like all technologized practices, the technological process is not neutral and is often influenced by ideologies. As critical makers, we need to ask ourselves, what is the goal of learning through making?

In recent discourses around making and makerspaces, there has been discernable language of exceptionalism and supremacy that privileges some over others in the overall maker experience. Gender representation is one of the most obvious; 85% of recent *Make:* magazine covers featured white boys or male teens playing with electronics and robots (Buechley, 2013). Additionally, books are situating the United States as the world's leading innovator and arguing that it should be rightfully so. A telling example is *Innovation Nation: How America is Losing Its Innovation Edge, Why it Matters, and What We Can Do to Get it Back* by John Kao (2007). Within the webspace, young makers are put in the limelight but with emphases that miss the point of making. In the case of "Caine's Arcade," (http://cainesarcade.com/) popular sources celebrate the maker culture with rhetoric of entrepreneurship, economic success, and technology-focused discourses—presenting "making" as a pathway to economic supremacy and dehumanizing the making process (see Figure 48). As scholars of rhetoric, technical communication, and technology studies, we need to pay attention to the ways making is represented in our classroom, and the intersections of the scientific and technical purposes of making with the social, historical, political, and the ethical. We need to ask critical questions about our course objectives and outcomes, representation and delivery, design and solutions, resistance and advocacy. Or, how might making best serve the needs of learning and teaching? These questions may shape the next iteration of this research.

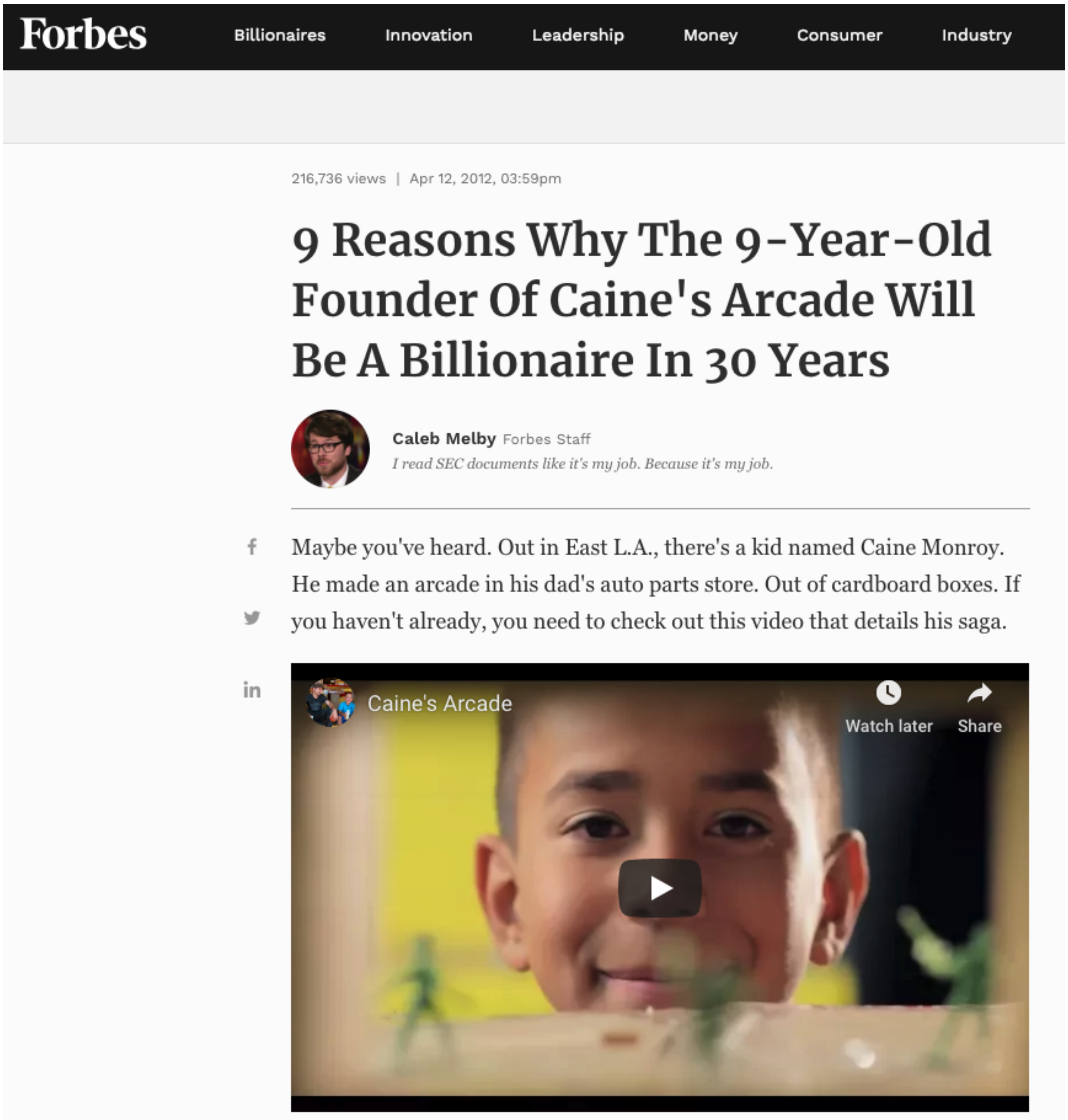

Figure 48. A *Forbes* article featuring "Caine's Arcade".

In sum, this dissertation is an exploratory study to understand academic making and its potential for TPC pedagogy. Based on initial findings from three on-site makerspace observations, I have developed a maker-based TPC course and assessed student learning in the course. Using student responses, evaluations, and reflections, I have devised a maker pedagogy framework for future deployment in TPC coursework. In my next project, I aim to study the viability of this pedagogical framework in various

TPC courses. I believe making and the maker culture will continue to tap into various aspects of our work in TPC, or writing studies at large. Making will draw attention to technology use, access and accessibility of learning spaces, representation of makers and their innovation, and other issues revolving around the constructions of literacy. TPC scholars and instructors must be responsive to these issues and continue to advocate for meaningful learning that corresponds with elements we deem valuable from academic making.

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APPENDIX A:

Course Syllabus - WRIT 3562W Technical and Professional Writing, Section 009, Fall 2017

WRIT 3562W Technical and Professional Writing

Fall 2017 | Department of Writing Studies | University of Minnesota

Instructor: Jason Tham
Email: thamx007@umn.edu
Office Hours: Wednesday 11am-1:30pm or by appointment
Course Moodle

About This Course

This 4-credit writing-intensive (WI) course is designed around a semester-long design challenge to help students acquire technical communication knowledge and competency in today's contexts. Students should expect to engage in active Agile collaboration and problem-solving activities driven by design thinking, rhetorical awareness, and multimodal composition frameworks.

Class meets **10:10am–11am** on **Monday** (Lind 340), **Wednesday** (Lind 340), & **Friday** (Appleby 321).

Readme: Technical communication, defined.

Course Objectives

This writing-intensive course will introduce students to and allow them to practice the following:

- Composing workplace genres such as memos, letters, proposals, instructions, and reports
- Explaining detailed and complex technical information to diverse audiences
- Rhetorically analyzing writing situations, multiple purposes, and potential audiences
- Designing visual and verbal information, and working with text arrangement and document design
- Understanding and practicing features of "readable" written communication
- Conducting research and clearly conveying results in written and oral formats
- Considering ethical implications and the ways knowledge, power, or human activity impact writing
- Conducting user testing of instructional documents and processes
- Working with others constructively through collaborative assignments

Major Frameworks and Methodologies

Major Technical Genres & Processes

Genres	Processes
- Analytical report - Technical definition & description - Visualization of data and findings - Instructions set - Memo	- Peer review - Agile collaboration - Usability testing - Professional presentation - Professional correspondence

Required Resources

- *Technical Communication Today, 6th edition* by Richard Johnson-Sheehan (2017)
- Access to Technology Training at UMN, including resources at Lynda.com
- Access to makerspaces: ETC Lab and Medical Devices Center
- Use of Google Drive for collaboration

Major Assignments

Week 2-4
Analytical report: Students will identify a problem on campus that could be addressed with existing/emerging technologies or technology-enhanced processes. Through observation, analysis, and data collection (such as qualitative interview, survey, and content analysis), students work in teams of three to identify a wicked problem within the campus community, determine researchable questions, and ideate ways to address their research questions. The goal of this 1000-word report is not to solve the problem per se, but to initiate a plan for a semester-long multimodal project. (15%)

Week 5-6
Technical definition and description: In a 500-word memo, each student team selects a technical term pertaining to their design project, and provides a concise definition of the specialized term. The definition should be accompanied by a detailed explanation of objects, places, or processes as the description of the technical term. (10%)

Week 5-10
Proposal of solution and prototyping: Each student team proposes a solution to the problem and/or research question they have identified in the analytical report. This 1000-word proposal of solution should be written with a specific audience in mind. The proposed solution must be prototyped either in a digital or physical form. The prototype must be turned in to the instructor and will be presented to the class at the end of semester. (25%)

Week 11-14
Instructions set: Each student team will organize and write an instructional procedure to enable a specific audience for the proposed solution of the identified problem. The instructions set must have at least 20 steps, include at least 5 visuals/illustrations, list the materials required, and include a warning/caution step. This set of instructions will be tested on by at least two users. The final instructions set should reflect revision based on the results of usability tests. (15%)

Week 15-16
Presentation: Each student team will organize and deliver a 15-minute professional presentation about their identified problems, design/prototyping processes, proposed solutions, and final prototype. (10%)

Week 15-16
Reflections: Each student produces a 500-word reflection narrative about their learning experience with the assignments sequence and the semester overall. (5%)

Grading

Quality of major assignments: **80%** (see individual assignment percentages above)
Engagement and participation: **20%** (including engagement with Agile process & attendance)

Final grade distribution will be as followed:

A	90-100%	C	72-74%
A-	87-89%	C-	69-71%
B+	84-86%	D+	66-68%
B	81-83%	D	63-65%
B-	78-80%	D-	60-62%
C+	75-77%	F	59% and below

Weekly Cadence

Monday (Lind Hall): Instructor-led discussions (concepts, assignments, etc.)
Wednesday (Lind Hall): 15-min scrum or sprint planning/review/retrospective; in-class discussions
Friday (Appleby Hall): Makerspace/work time (may not meet in class; to be announced weekly)

Course Policies

Attendance and engagement. Students are expected to attend every class and team activity session. I will lower your engagement and participation grade if you miss more than 3 sessions without legitimate reasons. You are expected to participate in all class activities (including team meetings) actively and productively. Given the 4-credit course load, you are expected to "study" for 12 hours each week.

Assignment and activity due dates. I do not accept late work. Students are responsible for communicating with me any challenges they face with meeting the assignment/activity deadlines.

Academic integrity. This course relies heavily on collaboration. I encourage you to offer each other suggestions and seek other opinions about your work. When you use the citable work of someone else, document your source. If you have questions about plagiarism, please ask me. I reserve the right to fail a student in the course for plagiarism, i.e., using other people's work without proper documentation and citation. See the UMN Student Conduct Code for details.

Accessibility and accommodations. Appropriate accommodations will be made for all students with documented disabilities. If you have a disability requiring accommodation, please notify me at the beginning of the course. This information will be kept confidential.

Potential Focus Areas for Design Challenge

Other ideas: Campus environment, waste management; student groups, extracurricular activities, event announcements (i.e., the "posting pillars"); student health services (physical, mental, spiritual); learning resources (temporal, sensorial); technology support.

WRIT 3562W Technical and Professional Writing
Fall 2017 | Dept. of Writing Studies | University of Minnesota | Inst. Jason Tham | Moodle

Course Calendar

Date	Readings/Topics	Assignments/To-Do's
Sept. 6	Introduction to the course. Review syllabus and assignment sequence. Ice-breaker exercise.	
Sept. 8	Introduction to design thinking, Agile collaboration methodology, and technical communication as a field. Read: ● What is design thinking (webinar optional) ● What is design thinking and why is it so popular ● TCT, Chapter 1: Technical Communication in the Entrepreneurial Workplace (pp. 1-20)	Submit pre-course diagnostic essay to Moodle by 11:55pm on Sunday, Sept. 10. Complete team-writing survey by 11:55pm on Sunday, Sept. 10.
Sept. 11	Design thinking orientation. Each student brings: Scissors, tape, marker pens, and scrap items like cards, woodsticks, boxes, napkins, etc.	
Sept. 13	Team assignment. Read: ● TCT, Chapter 3: Working in Teams (pp. 47-70) Scrum and sprint orientation. Introduction to Analytical Report assignment. Sprint planning for Analytical Report.	
Sept. 15	Teams meet to draft problem statement (meet in class). Communicating professionally. Read: ● TCT, Chapter 6: Emails, Letters, and Memos (pp. 137-175)	Send progress email to instructor by 11:55pm on the same day. (One email per team; copy all team members on the email.)
Sept. 18	Analytical Report: What's the purpose? What's included? Choosing a research direction/focus and defining your problem(s). Collecting data and using them to generate your design goals. Read: ● TCT, Chapter 10: Brief Reports (pp. 284-305); Chapter 14: Research in Technical Workplaces (pp. 389-419)	
Sept. 20	Scrum on Analytical Report assignment.	Each team emails an initial problem statement and timeline for data

	Teams present respective problem statements in class. Teams discuss data collection strategies and action plan.	collection to instructor by 11:55pm on the same day.
Sept. 22	**DEMO:** **ETC Lab** (Meet in class-- Appleby 321)	
Sept. 25	Teams meet outside of class to complete Analytical Report assignment.	Send progress email to instructor by 11:55pm on the same day.
Sept. 27	Teams meet outside of class to complete Analytical Report assignment.	
Sept. 29	Teams meet **in class** (Appleby) to complete Analytical Report assignment. Be prepared to share updates with instructor.	**Submit Analytical Report** to Drive by 11:55pm on Sunday, Oct. 1.
Oct. 2	Introduction to Technical Definition and Description assignment. What are technical definitions and technical descriptions? Read: ● TCT, Chapter 7: Technical Descriptions and Specifications (pp. 176-201) Introduction to Proposal of Solution and Prototyping assignment. Making, tinkering, and innovating as learning. Makerspaces and other resources on campus. Prototyping: How and why. Read: ● TCT, Chapter 9: Proposals (pp. 244-283) Check out Balsamiq and Moqups mockup applications. Check out InVision project management and user-testing tool.	
Oct. 4	Sprint review and retrospective for Analytical Report assignment. Complete continuous improvement report. Sprint planning for Technical Definition and Description assignment, and Proposal of Solution and Prototyping assignment.	
Oct. 6	Teams meet in class to complete Technical Definition and Description assignment, and/or Proposal of Solution and Prototyping assignment.	Send progress email to instructor by 11:55pm on the same day.
Oct. 9	Design and innovation: Technologies and their impact on society & technical communication Read: ● A Brief History of Technical Communication ● Gender, Technology, and the History of Technical Communication	
Oct. 11	**TOUR: Medical Devices Center** (Moos Tower, Delaware St SE, East Bank)	
Oct. 13	Teams meet to complete Technical Definition and Description assignment, and/or Proposal of Solution and Prototyping	**Submit Technical Definition and Description** to Drive by 11:55pm on

	assignment.	Sunday, Oct. 15.
Oct. 16	Audience analysis and the rhetorical situation. Crash course on rhetoric: Part 1 Read: ● Rediscovering Rhetoric: Persuasion for Technical Communication	
Oct. 18	Crash course on rhetoric: Part 2 Read: ● What's Practical about Technical Writing ● TCT, Chapter 2: Profiling Your Readers (pp. 21-36)	
Oct. 20	Teams meet to complete Proposal of Solution and Prototyping assignment. **Invitation: GPACW conference**	Send progress email to instructor by 11:55pm on the same day.
Oct. 23	Ethical dimensions of technical communication. Cultural considerations. Read: ● TCT, Chapter 4: Managing Ethical Challenges (pp. 71-98) ● The Ethic of Expediency: Classical Rhetoric, Technology, and the Holocaust	
Oct. 25	Scrum on Proposal of Solution and Prototyping assignment. Persuasive technical communication.	
Oct. 27	Teams meet outside of class to complete Proposal of Solution and Prototyping assignment.	Send progress email to instructor by 11:55pm on the same day.
Oct. 30	Elements of good design. Graphic design for marketing professionals. Read: ● TCT, Chapter 17: Designing Documents and Interfaces (pp. 476-506); Chapter 18: Creating and Using Graphics (pp. 507-529)	
Nov. 1	Color meanings exercise.	
Nov. 3	Exploring the capacities of the Internet and Web for technical communication. Read: ● TCT, Chapter 21: Writing for the Internet (pp. 594-616)	
Nov. 6	In-class review of work in progress.	Send progress email to instructor by

		11:55pm on the same day. (Taskboard review)
Nov. 8	Teams meet outside of class to complete Proposal of Solution and Prototyping assignment.	
Nov. 10	Review on Proposal/Prototype assignments Introduction to Instructions Set assignment. Composing effective instructional materials; usability and user experience (part 1) Read: ● TCT, Chapter 8: Instructions and Documentation (pp. 204-240)	**Submit Proposal of Solution (written portion)** to Drive by 11:55pm on Sunday, Nov. 12.
Nov. 13	Composing effective instructional materials; usability and user experience (part 2) Read: ● Chapter 19: Revising and Editing for Usability (pp. 530-552) Sprint planning for Instructions Set assignment. (Taskboard)	
Nov. 15	Professional writing, workplace communication. The presence & identities of a "writer" in professional contexts. Read: ● TCT, Chapter 12: Thinking Like an Entrepreneur (pp. 349-365)	
Nov. 17	Teams meet to complete Instructions Set assignment. Review instruction set draft (to be used in usability tests).	Send progress email to instructor by 11:55pm on the same day.
Nov. 20	Introduction of Presentation assignment. Elements of effective oral delivery. Read: ● TCT, Chapter 20: Presenting and Pitching Your Ideas (pp. 553-593)	
Nov. 22	Presentation and effective delivery, cont. Work in class to complete Post-Course Diagnostic Essay & Team-Writing Survey.	
Nov. 24	***NO CLASS: Give thanks***	
Nov. 27	Teams to meet with instructor in class: ● NextJEN (Jacob, Emmy, Nicole) ● Blonde Crew (Parker, Amanda, Paige) ● Bed, Bath, & Beyonce (Tushar, Rachel, Megan) ● Campus Creators (Sheryl, Shelby, George) Other teams meet outside of class to work on Instructions Set and Presentation assignments.	

Nov. 29	Teams to meet with instructor in class: ● THREE (Soey, Nicholas, Salma) ● Campus Commuting (Sally, Ali, Jaden) ● HAM (Hannah, Arthur, Michaela) ● The Incredibles (Tori, Eric, Devan) Other teams meet outside of class to work on Instructions Set and Presentation assignment in class.	
Dec. 1	Determining presentation order. Introduce final RATE reflection assignment.	Submit/Complete all of below by 11:55pm on Sunday, Dec. 3: **Post-Course Diagnostic Essay** **Team-Writing Survey** **Presentation Set** **Instructions Set**
Dec. 4	Team presentations ● NextJEN (Jacob, Emmy, Nicole) ● Bed, Bath, and Beyonce (Tushar, Rachel, Megan)	
Dec. 6	Team presentations ● Parker's team (Parker, Amanda, Paige) ● Campus Creators (Sheryl, Shelby, George)	
Dec. 8	Team presentations ● The THREE (Soey, Nicholas, Salma) ● The Incredibles (Tori, Eric, Devan)	
Dec. 11	Team presentations ● H.A.M. (Hannah, Arthur, Michaela) ● Campus Commuting (Sally, Ali, Jaden)	**Email RATE Reflection link** to instructor by Friday, Dec. 15.
Dec. 13	**LAST DAY OF CLASS** Review on Instruction Set and Presentation assignments. Revisit course objectives and accomplishments. Course evaluation.	