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Understanding and Tooling Translational Research in  
Human-Computer Interaction

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Abstract

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Successfully bridging research and practice in Human-Computer Interaction (HCI) can lead to better products and services that benefit society, as well as refined research questions and theories. However, groups of HCI practitioners and HCI researchers often fail to benefit from each other's valuable expertise, which led to the use of a "research-practice gap" metaphor to illustrate the hardships of bridging research and practice. Although the research-practice gap has framed and motivated studies and opinion pieces by HCI academics, there is still much to be understood about the relationships of research and practice in HCI. This dissertation investigates the nuances of the research-practice gap metaphor in HCI, and the knowledge exchange and use by different groups in the HCI community. Informed by such nuances, I design tools to bridge research and practice in HCI.

First, I investigate the research-practice gap to expose the complexity underlying the stark separation between two groups. I study HCI community members' current efforts to engage in Translational Research efforts, with a focus on knowledge consumption and utilization as well as barriers for knowledge to flow across groups. As a result, I propose a Translational Science Model using the concept of a continuum instead of a gap, to represent how knowledge flows in the HCI community through multiple gaps. I define and describe instances of Translational Research in the HCI field. In addition, I propose design considerations regarding the creation of resources and design methods to facilitate the translation of HCI knowledge from scientific findings to design. Through these contributions, the HCI community can better understand current practices around disseminating and translating HCI knowledge, and the challenges and opportunities for Translational Research to impact distinct design activities.

Second, to help bridge the research and practice gaps, I design and evaluate tools aimed at tackling specific barriers for Translational Research in HCI. Translational Research tools in HCI have been framed around academics' knowledge dissemination models and needs. In turn, I propose and evaluate tools focused on practitioners' needs and workflow. In one tool, I tackled the barrier of language by creating learning modules for HCI practitioners to read and understand theoretical concepts. On another tool, I tackled the barrier of applicability and contribute a design method to facilitate the application of existing theories into the design process. Learnings from these design explorations help to further furnish our

knowledge on how to effectively implement Translational Research efforts and provide additional nuance on the barriers for knowledge dissemination and translation in HCI.

In summary, this dissertation introduces and defines Translational Research in HCI and provides a foundation for the discipline to investigate and design translational processes and tools. Such contributions will hopefully inspire efforts to consolidate a Translational Science in HCI.

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# Glossary and Acronyms

## **Human-Computer Interaction**

I acknowledge that Human-Computer Interaction is a broad, diverse discipline that has evolved throughout the years (Bødker 2015). However, in the context of this dissertation, I will use Card et al.'s (1996) definition of Human-Computer Interaction as an applied discipline concerned with the design, evaluation, and implementation of interactive systems and with the study of phenomena surrounding them. I will often refer to Human-Computer Interaction using the acronym “HCI.”

## **HCI Practice and HCI Research**

Within HCI, several designations have been used to describe practice: “Interaction design” (Goodman et al. 2011; Norman 2010; Roedel & Stolterman 2013), “HCI practice” (Ogunyemi et al. 2019), or even “UX design.” Common to the terms is that they refer to a practice containing three key elements: what a professional does, what they experience, and in what context practice happens (Goodman et al. 2011). In essence, professionals in the HCI field carry out design activities to create products or services. They design or redesign artifacts but also make deals, develop code, investigate user problems, create product roadmaps, design agendas, recruit coworkers, and navigate company politics. These professionals may be visual designers who work with graphic expression, developers implementing code, or researchers conducting applied investigations. These professionals may work in consulting companies, in-house, or they may be self-employed.

Based on the previously mentioned definitions and my own understanding of practice in HCI, I define HCI practice as the process or practice of devising, planning, or constructing something, focusing on the design of effective, user-friendly, and interactive computing systems (Dix et al. 2003; Goodman et al. 2011; Velt 2018). I often refer to HCI practice as the work of interaction designers, user experience designers, user experience researchers, and software developers. This definition is somewhat limited but serves the scope of the studies in this dissertation.

Second, research is the active, thorough, and systematic process for gaining and broadcasting knowledge. Research within HCI focuses on how human-computer interactions affect people's work and activities (Dix, 2009). Research papers are often published at conferences and journals for an academic audience. Some concrete examples of knowledge that come from such research include theories, descriptions, and causal explanations and predictions (Shneiderman, 2016). Within HCI, practical knowledge, solutions, and guidelines may also be published.

In the context of this dissertation and based on my own understanding of research in HCI, HCI research is concerned with investigative and design processes that produce knowledge, enabling understandings and generalizations about phenomena in the interactions between people through and with technology. From here on, I refer to HCI research as the work performed by HCI scholars in academic environments, unless otherwise specified in the text.

## **Theory**

I use Yvonne Rogers's (2004) and Ben Shneiderman's (2018) definitions of theory as knowledge enabling understandings and generalizations about specific phenomena. Shneiderman even provides a list of instantiations of knowledge: theories (rules, frameworks, models), descriptions (terminology, taxonomies, ontologies), causal explanations and predictions, and more practical knowledge such as solutions (problem fixes, improved processes) and guidelines (recommendations, patterns, tutorials).

### **Research-Practice Gap**

The research-practice gap is a common metaphor used in many fields to describe the problematic relationships between research and practice. "The gap" implies a break or a hole sitting in between scholars and practitioners, between the theory and the practice of a discipline (Beck and Ekbia 2018).

### **Translational Research**

Translational Research refers to the study of the transformation of knowledge through successive fields of research from a basic scientific discovery to real-world impact (such as improving the health of the public), a complex process that requires the integration of theory-producing steps (basic and applied research) and practice-oriented steps (dissemination, implementation, design) (Rubio et al. 2010; Woolf 2008).

### **Translational Work**

Throughout this dissertation, I use the term "Translational Work" deliberately to talk about translations, or transformations of knowledge that occur—or do not occur—through successive steps of research and design activities.

### **Translational Science**

I broadly define Translational Science as an enterprise that systematically builds and organizes knowledge related to Translational Research. This definition is based on past work in Translational Medicine (Collins 2011; Rubio et al. 2010; Woolf 2008). Translational Science provides a greater understanding of Translational Research efforts, the stakeholders involved in translations, methods, informational resources, and technology.

### **Models**

Models are a simplification of reality to help in designing, evaluating, or otherwise providing a basis for understanding complex systems. It is convenient to think of models in a spectrum between metaphors and mathematical equations. Towards the metaphoric end are descriptive models; towards the mathematical end are predictive models. Predictive models allow metrics of performance to be determined analytically and allowing scenarios to be explored hypothetically (e.g., Fitts's law). Descriptive models provide a context for thinking about or describing a situation, often with a graphical articulation of categories or identifiable features of a system (Carrol 2003).

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# **Introduction**

The term “translation” denotes the activity of transforming knowledge from an original language or format into another for people who cannot speak the original language or understand and use the original format. “Translation” in the context of this dissertation describes the processes of mining research insights and honing them into practical, reliable, and useful results, or converting the problems and concerns of practice into clear information that can drive researchers to develop new insights (Norman 2010). The past few decades have seen an exponential increase in the output of scientific knowledge due to technological and methodological advances. Concurrently, industries, governments, and the public are interested in whether that scientific knowledge can be applied toward the betterment of society (Shneiderman 2016, Woolf 2008, Executive Order 13707 2015). The translation of scientific knowledge becomes a timely problem, considering the acceleration of scientific output and the widespread interest in making it “useful.”

A noticeable example of a Human-Computer Interaction (HCI) translation is the use of Goal-Setting Theory (GST) to design motivating interfaces. GST is a stable social psychology theory that has been widely influential in multiple fields such as management, sports medicine, as well as technology design. Locke and Latham’s findings on the principles of GST (1990) were developed with over 400 laboratory and field studies, showing that specific and difficult goals are likely to lead to a higher level of performance than vague and easy goals—such as “do one's best”—if a person is committed to a goal, has the ability to attain it, and does not have conflicting goals. In 2009, Consolvo et al. translated GST into an HCI research product called Ubifit, an application that turned phones’ displays into a flower garden that bloomed throughout the week as users performed physical activities. Around the same period, the company Fitbit used a flower element in their activity-tracking devices with the same goal-setting mechanism. Figure 1 on the next page shows a comparison of the two products. Later, Apple’s designers implemented a rather different version of GST with rings. Apple’s smartwatch displays three goals in their version of an activity tracker: Move, Exercise, and Stand, with each goal represented by a ring which fills to denote progress (Figure 1, right). Devices such as Fitbits and Apple Watches influence the lives of many who want to improve their health and have been incredibly successful in the market.



**Figure 1. Examples of activity trackers. Ubit on the left, Fitbit at the center, Apple Watch on the right.**

These translations of GST are relevant and consequential. Consolvo et al.’s paper is highly cited in the field of HCI, and Fitbit and Apple Watch sales are substantial. In the second quarter of 2019, Fitbit reportedly held 10% of the international wearable market, shipping nearly 3.5 million devices per quarter, behind the top three—Xiaomi, Apple, and Huawei, with market shares of 17%, 15%, and 14%, respectively (Rossolillo 2019). In late 2019, Google announced a definitive agreement to acquire Fitbit (Osterloh 2019).

A curious scenario emerges in which the connections between the original theory, the applied research engendered by Consolvo et al. (2009), and existing industry applications remain unclear. Did Fitbit specifically translate Consolvo et al.’s or Locke and Latham’s work into the flower that is so central to the user experience of the tracker? If GST is a successful design strategy for health-promotion tools, then how could more digital services make use of it? How can the HCI community provoke more and more frequent translations like this? In turn, what kind of information could academic researchers learn from applications which they could translate back into further studies, expanding or changing the theoretical understandings of GST?

In this context, HCI researchers, practitioners, and professional organizations have observed the existence of barriers preventing translations between research and practice. This has encouraged the use of the now well-known research-practice gap metaphor (Rogers 2004, Stolterman 2008, Buie et al. 2013). However, many of the existing scholarly contributions on this topic are opinion pieces without empirical data to support the authors’ arguments (Norman 2010, Stolterman 2008, Dourish 2006). This lack of empirical data suggests that scholars of HCI still lack the necessary knowledge of these barriers to use them as a framing device for the relationship between research and practice.

While the intention to “bridge” the research-practice gap with more translations to benefit society is a laudable one, realizing such an intention will be difficult to realize until translation work is better understood. The HCI field needs to further detail and understand the research-practice gap, investigating how HCI knowledge is translated, circulates, and informs—or does not inform—the work of different groups across the HCI community. Such understanding can support the design of successful Translational Research and the development of a Translational Science in HCI.

## **Problem Statement and Outline**

The HCI community has used the research-practice gap metaphor to engage with issues of knowledge translation. However, the gap metaphor seems to be an understudied facet of the relationships between design and research in HCI. This can be a source of confusion, considering that diverse interdisciplinary fields such as HCI encompass not only two groups, but a range of groups with differing goals, settings, practices, and knowledge. This in turn may cloud the proper identification of translational barriers and prevent the allocation of resources to the appropriate efforts.

Detailing the Translational Research space in HCI remains necessary to support the design of translational tools and the development of a Translational Science in HCI. Investigating the problems, limits, and opportunities around the gap metaphor will ease how scholars of HCI choose to explore translational barriers and research-practice engagements. As such, the general objective of this dissertation is to contribute a detailed understanding of Translational Research in HCI, its barriers and translational processes, and tools for knowledge translation. Specifically, I do the following:

- Analyze existing models and metaphors related to Translational Research, fetching literature from other fields that are more mature in Translational Science than HCI. I draw from the works of influential authors in the HCI community (for example, Norman 2010, Stolterman 2008, Shneiderman 2018, Beck and Ekbja 2018, Gray et al. 2014, and Yvonne Rogers 2004) and compare them with works from other applied fields such as medicine and education (for example, Drolet and Lorenzi 2011, Woolf 2008, Rubio et al. 2010, and Stafford-Brizard et al. 2017).
- Triangulate the literature analysis with firsthand accounts of HCI community members, resulting in a model of Translational Science in HCI.
- Report on my process to generate and evaluate two translational tools following an in-depth understanding of translational barriers and HCI practitioner needs.

In this dissertation, I go from understanding the research problem in depth to proposing alternative tools to conduct Translational Research in HCI. In the background chapter, I present the general literature that informs the work in this dissertation, literature that is particularly concerned with the metaphors and models for representing and discussing the relationship between research and practice. In Chapters 3 and 4, I describe investigations that can improve how the HCI community describes and engages with Translational Research. In Chapter 3, I describe the nuances of the research and practice relationship in HCI. Such nuances informed the creation of a model that expands the traditional narrative outlined by the research-practice gap metaphor. In Chapter 4, I present the findings of a study that details the informational needs and practices of HCI practitioners. I outline the informational resources that inform—and the translational barriers that prevent theory from informing—specific design activities, and I propose strategies for designing theory-driven resources to find their way into practitioners’ information consumption and use. In Chapters 5 and 6, I report on my efforts to bridge research and practice with strategies that tackle specific translational barriers that I identified in Chapters 3 and 4. In Chapter 5, I tackle the understanding barrier. In Chapter 6, I tackle the *Applicability* barrier. Finally, in the discussion chapter, I put the findings in perspective and envision a future of Translational Science for HCI. See a summary outline of the dissertation on Table 1.

**Table 1. Outline of the dissertation.**

<b>Ch. Topic</b>	<b>Question</b>	<b>Description</b>	<b>Contribution</b>
3 Understanding the research-practice gap	What model for translation describes the translational gaps and activities across HCI?	The research-practice gap metaphor does not sufficiently account for the various groups and translations that exist across the discipline. I contribute a nuanced understanding of Translational Research in HCI in the form of a Translational Science Model. The model details multiple gaps and translations between research and practice using the T-terminology.	Empirical Contribution 1. Understanding the barriers in HCI translations  Artifact Contribution 1. Translational Science Model of HCI
4 Understanding the informational needs of HCI practitioners	What resources do HCI practitioners use to inform their work? How do HCI practitioners use these resources?	The most common gap in HCI literature is between academic research and HCI practice. First, I contribute in-depth descriptions of barriers for the use of academic research findings in HCI practice. Second, I explain how HCI practitioners use nonacademic informational resources to inform four design activities: understanding, brainstorming, building, and advocating.	Artifact Contribution 2: Taxonomy of informational resources driving design activities
5 Tackling the translational barrier of Understanding	How to facilitate nonacademics' reading and understanding of scientific research?	I designed and evaluated a learning module to facilitate the understanding of scientific publications. The module helped HCI students to navigate scientific publications and understand them. I contribute insights for educators and the module itself.	Artifact Contribution 3: Active reading exercises for understanding theories
6 Tackling the translational barrier of Applicability	How to facilitate the use of scientific findings in the design process?	I designed and evaluated the Behavior Change Design Sprints method (BCDS). BCDS facilitates the quick translation of theoretical concepts into prototypes, without needing to engage with the research-producer or conducting research. I contribute insights for HCI educators and the method itself. BCDS serves as the basis of a graduate-level course in the Human Centered Design and Engineering department at the University of Washington.	Artifact Contribution 4: sprints for prototyping theory-informed designs

The approach to this dissertation is inevitably influenced by my personal background. So far in my career I have embraced research, design, and teaching, in industry and academia, in Brazil and in the United States of America. The nature of my personal and professional background informs the ways I chose to investigate, implement, and explain Translational Research in HCI.

# Background

In this chapter, I articulate influential work that exemplifies the research-practice narratives from multiple fields. Academics have described the relationships between research and practice with metaphors such as “gaps,” “chasms,” and other expressions based on the concepts of diffusion and translation of knowledge. I follow the tracks of highly cited models describing research-practice relationships and strive to represent the evolving state of Translational Research.

## Knowledge Dissemination Models

In this section, I present three traditional, highly cited models of knowledge dissemination: the Sender-Receiver Communication Model, the Innovation Diffusion Model, and the Linking Systems Framework (Shannon 1948, Shannon and Weaver 1963; Everett Rogers 1962; Robinson 1993).

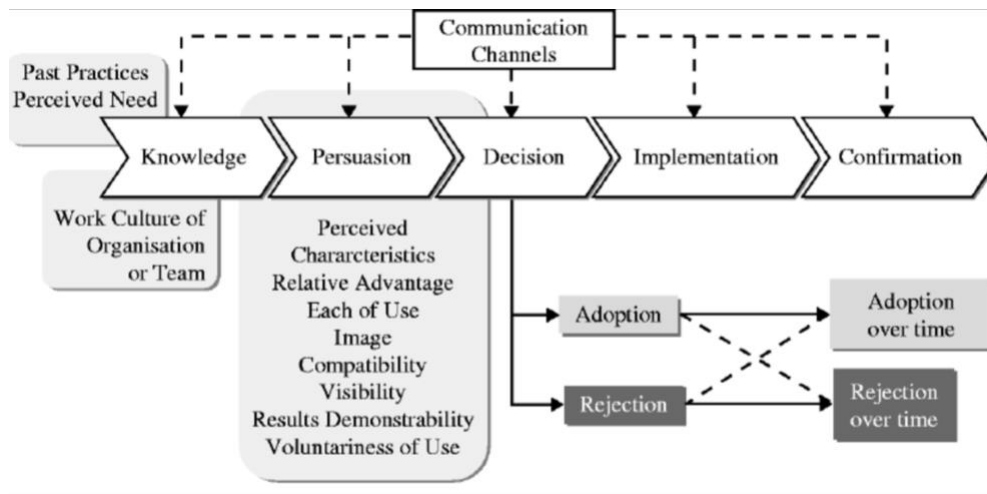
The Shannon-Weaver model of communication has been called the “mother of all models” (Shannon 1948; Shannon and Weaver 1963). See a representation of the Sender-Receiver Model in Figure 2 below. This classic model of communication comprises three main parts: the *sender* sends a *message* through a channel to a *receiver*. In the context of the gap between research and practice, the sender is an academic, the message is a scientific research finding, and the receiver is a practitioner. According to the mechanism put forth by this model, a researcher intends for their scientific findings to be useful and applicable to practitioners. If practitioners do not find utility or relevance in the message, that is considered a communication gap, which Shannon suggests can be addressed by modifying the message.



**Figure 2. Sender-Receiver Model.**

Drawing on the foundation established by the communication model, Rogers (1962) developed the Innovation Diffusion Model, which has since inspired a multitude of fields to study Translational

Research. As Shannon, Rogers’s model follows an objective approach, attempting to find unambiguous and accurate variables to structure translation flows. See a representation of the Innovation Diffusion Model below in Figure 3. Rogers’s model was developed mainly in the context of research in Rural Sociology and Medical Sociology. In this model, knowledge (or innovations) originates often from a research and development organization or an academic research lab that is interested in the diffusion of knowledge. This source then diffuses knowledge to adopters, who may accept or reject it. In Medical Sociology, such concepts were investigated in case studies of how doctors prescribed or avoided prescribing newly introduced antibiotics. Similarly, Rural Sociology studied government agencies working to disseminate the use of new hybrid corn varieties (Rogers 1962).



**Figure 3. Innovation Diffusion Model.**

Shannon-Weaver’s model and Everett Rogers’s model established a strong and lasting foundation for the study of knowledge translation and diffusion, influencing decades of studies in multiple fields. In 1993, Robinson described the Linking Systems Framework (Robinson 1993, Figure 4 on the next page), an influential model from the field of Education. Robinson emphasized strategies to connect theory and practice by considering the needs and concerns of the practitioner audience—in this case, teachers and school administrators—in the diffusion of scientific findings. Robinson highlights that research may be ignored, regardless of how skillfully it is communicated, because it bypasses the problem-solving processes that sustain the practices that researchers seek to alter. Therefore, Robinson proposed that it may be more helpful to think of translational processes by anticipating and coordinating with the requirements and characteristics of future contexts of use.

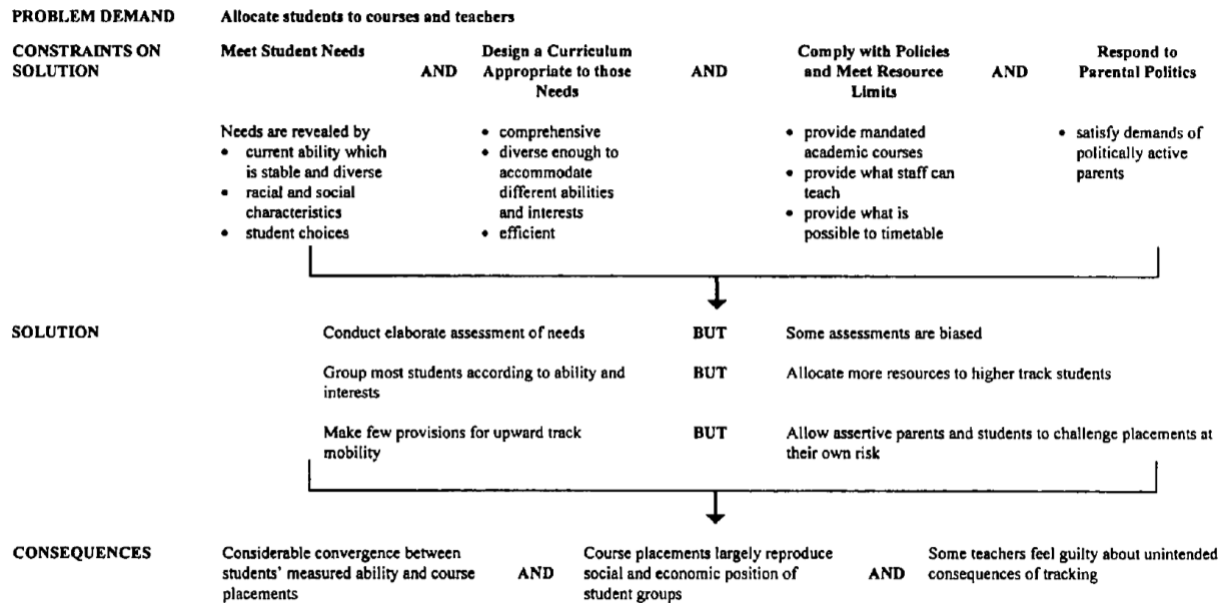


Figure 4. Linking Systems Framework.

The models described above demonstrate a curious contrast between two ways of seeing translation. The first two models, originally published in the 1960s, denote a “push” model of knowledge flowing from a central legitimizing source into the hands and minds of practitioners. A few decades later, Robinson’s model proposed a user-centered approach to connecting theory and practice, where the needs of the practitioner audience are treated as crucial aspects for solving translational problems. The contrast between the formative models and the newer model coming from the field of Education highlighted the necessity to keep studying models of knowledge translation from different fields and progressing beyond the early 1990s, which is what I do next.

## Translational Research in Medicine

In this section, I discuss the main milestones of Translational Medicine and review the five most-cited Translational Research models in Medicine (Greenhalgh et al. 2004; Fixsen et al. 2005; Wandersman 2008; Rubio et al. 2010; and Drolet and Lorenzi 2010). To do so, I probed the biomedical literature via MEDLINE<sup>1</sup> and PubMed<sup>2</sup> searches.

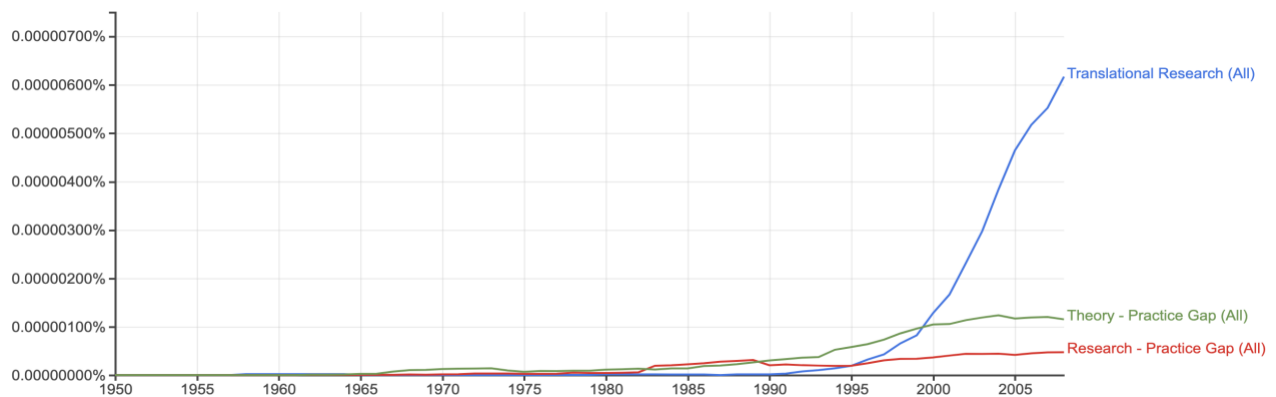
“Translational Research” is now a pervasive term in the biomedical domain. It is presented as a crucial way to bridge the gap between knowledge produced at the lab and its use at the clinical level. The current definition for “Translational Medicine” (Translational Research in the Biomedical fields) broadly refers to the enterprise of harnessing knowledge from basic sciences to produce new drugs, devices, and treatment options for patients and is essential for improving public health (Woolf 2008). Translational Medicine

<sup>1</sup> MEDLINE is the U.S. National Library of Medicine (NLM)’s premier bibliographic database that contains more than 25 million references to journal articles in life sciences with a concentration on biomedicine (Medline n.d.).

<sup>2</sup> PubMed is a free search engine accessing primarily the MEDLINE database of references and abstracts on life sciences and biomedical topics. The NLM at the National Institutes of Health maintain the database (PubMed n.d.).

also helps society harvest the health benefits of its investments in scientific research (Fontanarosa and DeAngelis 2002; Van der Laan and Boenink 2012).

However, the definitions and goals of Translational Research in biomedicine fields have not always been clearly demarcated. Translational Research in biomedicine is a somewhat recent formal enterprise, which has led to interesting developments related to nomenclature, formation as a subfield, and consolidation. The very use of Translational Research as a term started in the 1990s, largely influenced by well-funded projects dedicated to translating knowledge and investigating how knowledge is translated. Figure 5 illustrates the growth in the use of “Translational Research” in a corpus of books published until 2008 compared to “theory-practice gap” and “research-practice gap,” which have plateaued. This is a Google Books Ngram search (Michel et al. 2010), which normalizes the results using the number of books published each year.



**Figure 5. The term “Translational Research” has seen exponential growth since the early 21st century.**

The earliest mention of “Translational Research” on PubMed is a 1993 paper by Mulshine et al. Van der Laan and Boenink (2015) attributed the 1993 milestone to the establishment of the Specialized Programs of Research Excellence by the U.S. National Cancer Institute (NCI) in 1992. In response to concerns that scientific knowledge was not effectively applied to reduce the burden of cancer, specialized programs encouraged Translational Research to promote interdisciplinary research and to accelerate the move of basic research findings from the laboratory to applied settings involving patients and populations. The NCI also was the first to link the term “Translational Research” to the colloquialism “from bench to bedside”:

Translational Research moves knowledge about cancer in either direction, between findings at the laboratory bench and clinical observations at the bedside. Both preclinical and clinical research are translational if the specific goal is to move the fruits of basic knowledge closer to clinical application. (Broder and Cushing 1993, p. 477)

From 1993 until 1995, 16 papers mentioning “Translational Research.” These papers reported results of investigations on different forms of cancer. In this first batch of papers, the term was used in research on the discovery and validation of biomarkers for cancer prevention, which held potential for accelerating and reducing the costs of prevention. The first paper to ever mention Translational Research (Mulshine et

al. 1993) discusses how to turn a cancer biomarker into a clinical application. In this paper, the authors mention Translational Research explicitly:

(...) biologic tools reflecting the early stages of the cancer process need to be validated for use in serially evaluating the status of the relevant epithelium so that the ongoing success of a cancer intervention procedure can be established. Through this type of translational research, important applications of molecular biology may greatly improve the success of preventative strategies for cancer control (p. 978).

And implicitly:

The significance of inappropriate or overexpression of specific pulmonary cell products is an important basic research question that has translational significance in establishing relevant targets for intermediate endpoint application (p. 981).

By providing a window into the biology of the epithelium, biomarkers can have a number of applications for the management of individuals with cancer or at risk for cancer. A single biomarker or, more likely, panels of individual biomarkers, when rationally assembled, may be used to provide a clear picture of the state of cancer progression (p. 979).

In 1997, Translational Research appeared in the name of new research centers in Canada and the United States. Such centers created tissue banks and alliances between researchers working on different stages of cancer research and private partners. In subsequent years, the term was taken up outside North America and also in other subdisciplines such as AIDS research, cardiology, and gastroenterology, eventually losing its association with cancer research to be used in all areas of biomedical research (Van der Laan and Boenink 2015). Today, the term is used in studies spanning different types of research (e.g., immunology studies, from basic to clinical research) and the work of different areas within a particular type of research (e.g., molecular genetics, immunology) (Rubio et al. 2010).

A turning point for Translational Research in Medicine seems to have been the year 2003. The completion of the Human Genome Project, a lavishly funded “big science” project, failed to bring about the promised revolutionary changes in healthcare (Van der Laan and Boenink 2015). Also, in 2003, the existence of “gaps” for how medical research leads to real improvements in health was directly targeted by the American National Institutes of Health (NIH) in the “Roadmap for Medical Research” (Zerhouni 2003). This roadmap outlined clear strategies to tackle gaps and roadblocks that hamper the transformation of the discoveries in life sciences into health improvements for society.

By engaging seemingly unrelated disciplines, traditional gaps in terminology, approach and methodology also are gradually eliminated. With roadblocks to potential collaboration removed, a true meeting of minds can take place that broadens the scope of investigation into biomedical problems, yields fresh and possibly unexpected insights, and may even give birth to new hybrid disciplines that are more analytically sophisticated. By establishing new awards aimed at building interdisciplinary research teams, NIH hopes to help

accelerate research on diseases of interest to all of its institutes, centers and offices with an eye toward improving the nation’s public health. (Zerhouni 2003, p. 331)

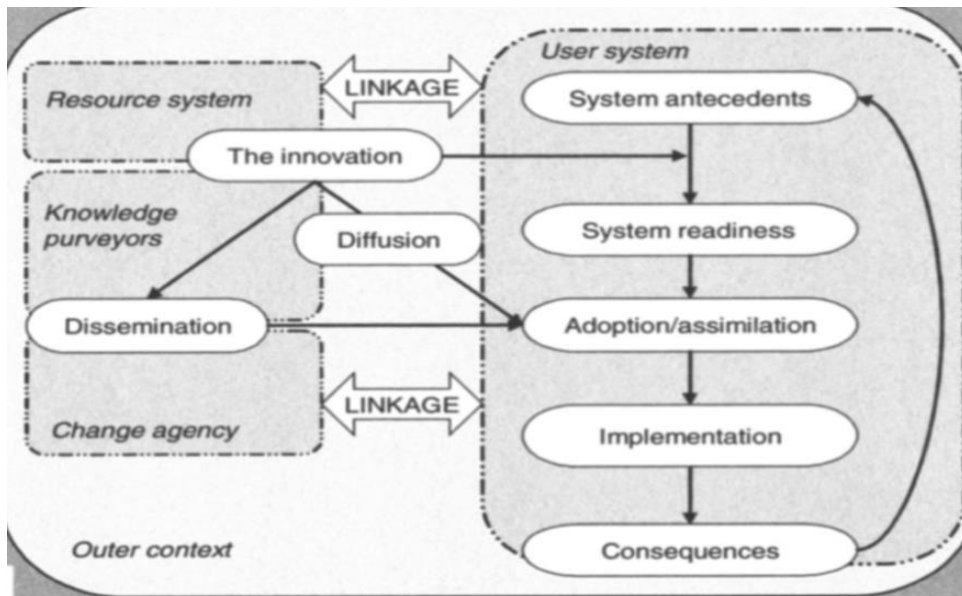
Following the 2003 milestone there was a massive growth in the number of publications mentioning Translational Research in biomedical fields (Table 2):

**Table 2. Growth in publications mentioning Translational Research in biomedical from 2001 to 2020.**

<b>5-year periods</b>	2001 to 2005	2006 to 2010	2011 to 2015	2016 to 2020*
				*until late March 2020
<b>Number of publications</b>	657	2,922	10,926	23,168

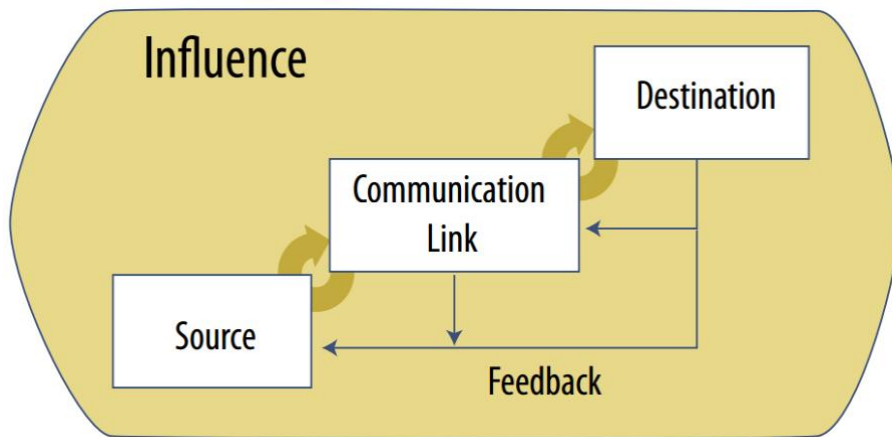
Interestingly, after 2003, the Translational Medicine models that emerged have had a strong focus on system’s thinking and interdisciplinarity. Such change in focus might have occurred because of the NIH push for academics to engage across disciplines, integrating approaches and methodology to facilitate collaboration. The NIH specifically started funding interdisciplinary research teams, (Zerhouni 2003). The community agreed that in order to realize Translational Medicine, many different translational activities needed to be performed by different groups in different settings.

The Linkage Model of diffusion, dissemination, and implementation of innovations in health service delivery and organization (Greenhalgh et al. 2004) focuses on providing guidance to change agencies. Greenhalgh et al.’s work is based on an immense review of 495 studies. Although authors describe the many nuances of Translational Research strategies, the authors say the model is intended mainly as a memory aide for considering the complex and shifting aspects of knowledge exchange between different actors and systems. See the Linkage model in Figure 6.



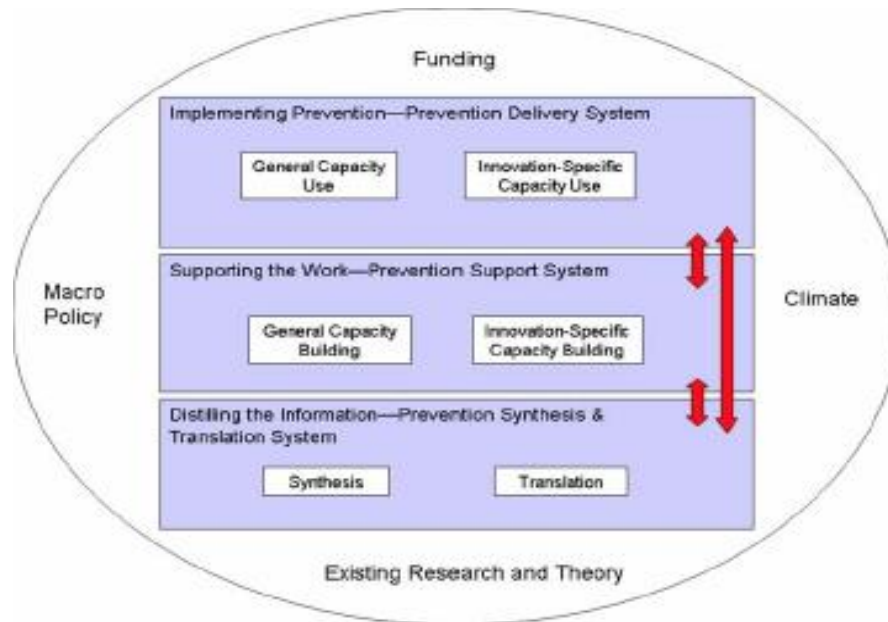
**Figure 6. Linkage Model.**

The Framework for Implementation of Defined Practices and Programs (Fixsen et al. 2005) is broadly geared towards Public Health, mentioning the benefits of using an organized framework for mental health, social services, juvenile justice, education, early childhood education, employment services, and substance abuse prevention and treatment. Fixsen et al. provide a textbook for translational researchers preparing an implementation process, explaining how to use the model and a framework to create an implementation process for the adoption of new knowledge. The focus of the model is on staff selection as opinion leaders—paying special attention to those who implement programs and policies related to evaluation and measurement of the success of translational programs. Fixsen et al. also offer an extensive guide on how to implement the framework, which does not exist in other reviewed work. See the Framework for Implementation of Defined Practices and Programs in Figure 7.



**Figure 7. Framework for implementation of defined practices and programs.**

The Interactive Systems Framework for Dissemination and Implementation (Wandersman et al. 2008) is intended to be used by different stakeholders (e.g., funders, practitioners, and researchers) to better understand the needs of other stakeholders and systems. See the Interactive Systems Framework for Dissemination and Implementation below in Figure 8. This framework tries to accommodate multiple perspectives, such as the perspective of the funder, researcher, practitioner, or technical assistance provider. The bottom box represents efforts to distill information about innovations and translate it into user-friendly formats. The middle box represents efforts to support the work (e.g., training) of those who put the innovations into practice in the field (Prevention Support System). The top box represents efforts to implement innovations in the world of practice.



**Figure 8. Interactive systems framework for dissemination and implementation**

Although Greenhalgh et al.’s, Fixsen et al.’s, and Wandersman’s models appropriately describe and organize different groups that perform translations, the models use wildly different terms and represent gaps in different ways. An influential article in 2008 pointed out that “translational research means different things to different people” (Woolf 2008), which had many negative implications for resource allocation and translational programs development, claims substantiated in Rubio et al. (2010). According to Woolf (2008) and Van der Laan and Boenink (2015), Translational Research and Translational Medicine had become convenient shorthand for a variety of different types of studies (the development of biomarkers, performing the first clinical studies of a new technique, the marketing of a newly developed medical technology, and the formulation of clinical guidelines) and different kinds of contributions (bridging basic research and medical innovation, translating research into medical practice, and translating science into better healthcare). For Woolf and Van der Laan and Boenink it is misleading to label different Translational Work simply as “Translational Research” or “bench-to-bedside,” because it suggests that Translational Research is one or all types of research.

As a response, Woolf offered a now widely used, broad definition of TR as the essential work of improving population health through an interface between basic science and clinical medicine— harnessing knowledge from basic sciences to produce new drugs and treatment options that can be used clinically or commercialized (Woolf 2008). However, as the blanket term “Translational Research” for different types of translations showed limitations because of the variety of settings, study designs, and investigators involved in the translational process, Woolf and Rubio have also incentivized the use of the T-terminology. The T-terminology was introduced by Dougherty and Conway in 2008, where “T” indicates “translation” and is accompanied by the numbers 1, 2, and 3 to represent the three major translational steps that, according to the authors, face different challenges:

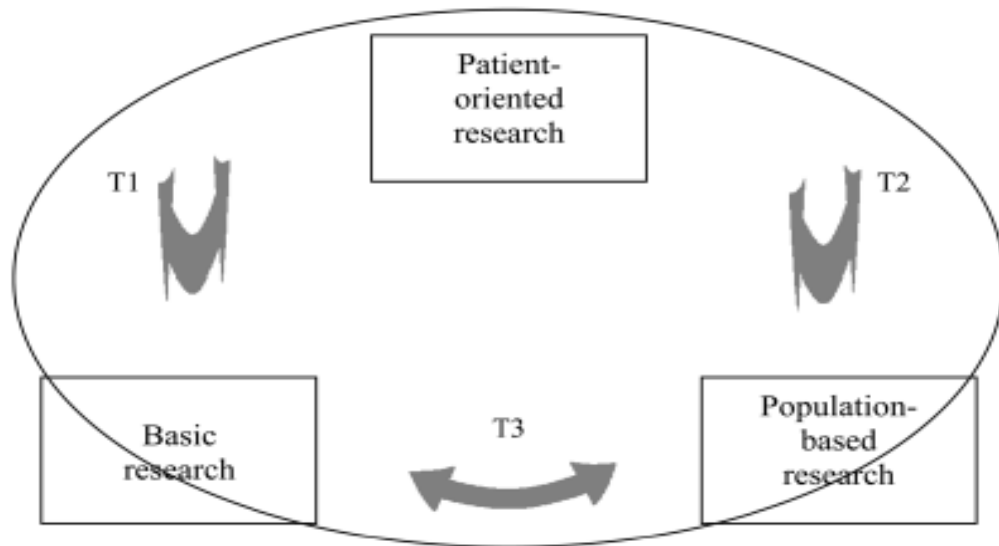
- T1 research requires mastery of molecular biology, genetics, and other basic sciences, appropriately trained clinical scientists working in strong laboratories and with cutting-edge technology, and a supportive infrastructure within the institution. T1 struggles more with biological and technological mysteries, trial recruitment, and regulatory concerns. Randomized clinical trials often produce knowledge that is valid for a very specific group of patients only. From this perspective, the translational gap is at least partly created by the artificiality of experimental set ups. This artificiality sits badly with the complexity of real-world settings and is expressed through internal and external validity tensions (Van der Laan and Boenink 2015).
- T2 tests who benefits from promising care, comparative effectiveness research, and health services research. The “laboratory” for T2 research is the community and ambulatory care settings, where population-based interventions and practice-based research networks bring the results of T1 research to the public. T2 requires different research skills: mastery of the “implementation science” of fielding and evaluating interventions in real-world settings. T2 also requires mastery of the disciplines that inform the design of those interventions, such as clinical epidemiology and evidence synthesis, communication theory, behavioral science, public policy, financing, organizational theory, system redesign, informatics, and mixed methods/qualitative research. T2 struggles more with human behavior and organizational inertia, infrastructure and resource constraints, and the messiness of proving the effectiveness of “moving targets” under conditions that investigators cannot fully control.
- T3 tests how to deliver high-quality care reliably in all settings, measuring quality and cost, implementing interventions, redesigning healthcare systems, and scaling and spreading effective interventions. T1 and T2 outputs are focused on strictly medical perspectives, and T3 involves other fields to translate medical research into practice. For example, medical research can inform choices about health habits (e.g., diet and smoking), environmental policy, injury prevention, parenting, healthy workplaces and schools, and population health campaigns. The practitioners who apply evidence in these settings include researchers and academics from multiple fields, patients, psychologists, public health administrators, employers, school officials, product designers, the food industry, and others. Van der Laan and Boenink (2015) state that translational researchers should consider a huge variety of outcomes, translating knowledge into technologies, practices, methods, datasets, policies, etc.

Multiple authors (Dougherty and Conway 2008; Woolf 2008; Rubio et al. 2010; and Van der Laan and Boenink 2015) stress that the T-terminology helps researchers to visualize how fields allocate resources. In Medicine, this is consequential because T2 and T3 are closer to immediate impacts in people’s lives compare to T1. T1 occasionally yields breakthroughs that markedly improve the prognosis for a disease, but most new drugs and interventions produced by T1 only marginally improve treatments’ efficacy. These incremental advances are certainly appreciated, but patients might benefit more and on a larger scale if the healthcare system performed better in delivering existing treatments than in producing new ones.

Two ordinary problems exemplify such a perspective. First, better targeting of aspirin might prevent more strokes than the development of more potent agents. Second, common techniques for the

administration of intramuscular injection are not evidence based, resulting in confusion and improper patient care (Greenway et al. 2019). Therefore, T2 and T3 are more likely to decrease morbidity and mortality than a new imaging device or class of drugs (Woolf 2008). A guarantee that biomedical science will lead to benefits for society is impossible to give, but continuously and intentionally connecting research to the future use of its results may be best for harvesting the benefits of science (Van der Laan and Boenink 2015).

After 2008, based on the usefulness of the T-terminology, researchers have produced more complete and useful models. It is also clear at this moment in time that translational researchers have started moving away from a focus on dissemination after learning through trial and error that only investing in dissemination of theories demonstrated low returns on investments, as theory fails to impact practice when it does not have a clear understanding of a practitioner’s context and complex processes of translation, such as adaptation or rejection of new knowledge (Tabak et al. 2012). From drawing on the T-terminology and from such understanding emerged the two most influential models of Translational Medicine currently in use.

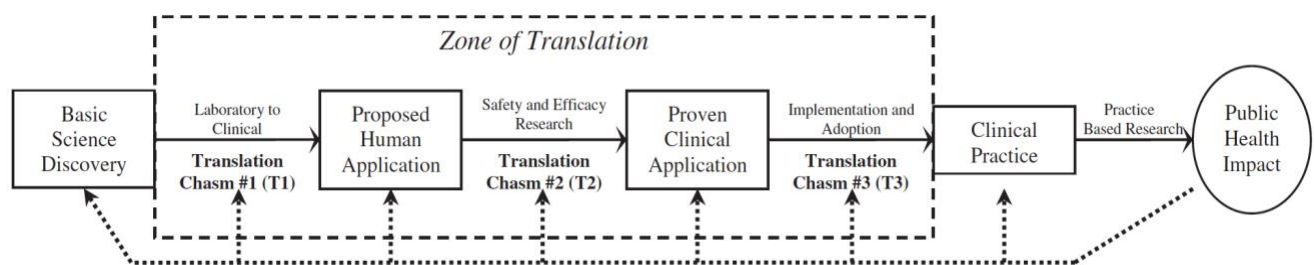


**Figure 9. Model for clinical translational research.**

The Model for Translational Research (Rubio et al. 2010) comes from clinical research and lays out a nexus of knowledge translations between basic research, patient-oriented research, and population-based research. Interestingly, Rubio et al. explain that the end point of the model is the health of the public: for example, producing a new drug or treatment and then ensuring that new treatments and drugs reach the patients or populations for whom they are intended and are implemented correctly. This model is targeted specifically for those responsible for Translational Research programs, which may be why it emphasizes the importance of having specific goals as well as the importance of “implementation.” Authors mention many times that implementation strategies such as training professionals in Translational Research are critical. See the Model for Clinical Translational Research above in Figure 9.

Using a similar concept, Drolet and Lorenzi (2010) proposed the Biomedical Research Translation Continuum, illustrated in Figure 10 below. The most important aspect of this model is how it represents the progression of knowledge through different disciplines and activities with a clear division of steps using the T-terminology. The now-ubiquitous T-terminology, as used by Drolet and Lorenzi, shows three translational gaps (T's) which according to the authors are the main landmarks in knowledge progression in the continuum. The first gap (T1) transfers knowledge from basic research to clinical research, while the second gap (T2) transfers findings from clinical studies or clinical trials to practice settings and communities, where the findings improve health. T3 requires implementing applying and evaluating interventions in real-world settings through interplay of the disciplines that inform the design of those interventions, such as Clinical epidemiology, Communication theory, Behavioral science, Public policy, Financing, Organizational theory, Design, Informatics.

Importantly, Drolet and Lorenzi argue that the continuum model supports Translational Research by refining discussions of translation and allowing more precise identification of barriers to progress. Hence, translational researchers may use the continuum to understand and describe their Translational Work within a well-defined conceptual framework.



**Figure 10. Biomedical research translation continuum.**

## The Research-Practice Gap and Translational Research in HCI

The research-practice gap metaphor is used in HCI to describe an undesired space that exists between the research and the practice of the discipline (Buie et al. 2013; Remy et al. 2015; Gray et al. 2014; Beck and Ekbia 2018; Goodman et al 2011; Roedl and Stolterman 2013). Putnam (2010) theorizes the semantic benefits in illustrating the relationship between research and practice as a gap. They mention that the narrative purported by the gap metaphor and a ‘barriers framing’ are useful rhetorical moves to start useful conversations about the relationships between practice and research in the HCI field.

HCI academics have discussed minute and structural barriers as reasons for theory not being used by practitioners to do design work. Many important academics (e.g., Buie et al. 2013; Dalsgaard & Dindler 2014; Höök & Löwgren 2012; Rogers 2012; Gaver 2012; and Roedl and Stolterman 2013) have suggested that HCI findings are too abstract, difficult for practitioners to learn and apply, are deficient in their ability to account for all of the decisions that designers confront, are often couched in jargon, are overly technical, and are sometimes simply irrelevant to practitioners. However, these barriers go deeper.

Although most HCI academics support the idea of producing actionable insights for practitioners, it has been observed that they often fail to structure research plans in ways that lead to societal benefits (Butler 1986; Stolterman 2008; Koskinen et al. 2011; Shneiderman 2018). Some authors even question if the time and energy devoted to HCI research is worthwhile, since it is largely ignored by design practitioners. For Norman (2010) and Shneiderman (2018), the close connection to research and separation from design practice have been continuous hallmarks of the community and Association of Computing Machinery (ACM) -sanctioned HCI conferences and journals.

The gap metaphor has inspired HCI researchers to tackle these barriers. A common approach found in literature is the proposal and evaluation of intermediate-level knowledge objects translating theory for practitioner use. Researchers have proposed strong concepts, bridging concepts, principles, and heuristics (Höök & Löwgren 2012; Dalsgaard & Dindler 2014) as research-practice gap bridges. Multiple research-practice bridging interventions appear in papers, such as Buie et al., 2010; Detweiler, Pommeranz, & Stark 2012; Judge et al. 2010; Rosner et al. 2012; Sellen et al. 2014; Dalsgaard & Dindler 2014; Goodman, Stolterman, & Wakkary 2011; Remy et al. 2015; Roedl & Stolterman 2013; Höök & Löwgren 2012; and Löwgren 2013. See descriptions of relevant work below in Table 3.

**Table 3. Sample of HCI scholarship translating theory into resources for design practitioners.**

Evaluated how Slow Design principles from scientific research could influence design practice. Authors translated Slow Design principles into cards for practitioners to generate juicer ideas. An analysis of ideas showed that the principles were not influential in the design process. Participants required more examples of Slow Design projects in order to understand the principles, which were considered too abstract. Even with examples, participants' interpretation of Slow Design principles varied greatly.	Grosse-Hering et al. 2013
Proposed guidelines for improving the presentation of research findings. The proposed guidelines were not evaluated.	Roedl and Stolterman 2013
Proposed bridging concepts to facilitate exchange between theory and practice in HCI, attending to abstraction as the dominant problematic feature in the gap. The proposed concepts were not evaluated.	Dalsgaard and Dindler 2014
Studied how Sustainable Interaction Design principles that originated in scientific research could make environmental sustainability a central focus in design practice. Authors created cards based on the principles, which were used by practitioners in design workshops to generate sustainable artifacts. When experts analyzed the artifacts generated in the workshops, it was clear that principles were not as influential in the design process as authors hoped.	Remy et al. 2015

As much as the gap can be useful as a conversation starter and as inspiration for intervention studies, a close analysis of the HCI literature reveals a concerning pattern: work related to the research-practice gap is often based on authors' unique personal experiences rather than empirical investigations of Translational Research. Often-cited papers on the research practice gap in HCI (e.g., Rogers 2004 and

Sutcliffe 2000; Roedl and Stolterman 2013; and Stolterman 2008) do not provide evidence of barriers to substantiate the research-practice gap or the lack of theoretical contributions being applied to design practice, nor do they study the reasons for the existence of such barriers and their nuances. Not knowing enough about “problems” is a critical concern when it comes to interventionist problem-solving research. Carrol (2013) and Buie et al. (2010) claim that the HCI field does not know enough about the gap and its barriers or the extent to which they may be grounded more in perception than in phenomena. For Buie et al. (2010):

We do not know the nature, the magnitude, or the dimensions of the problem, or the extent to which it may be grounded more in faulty perception than in reality. Until these issues [barriers] are better understood, there is little hope of identifying workable remedies and setting achievable goals for overcoming the problems (p. 3182).

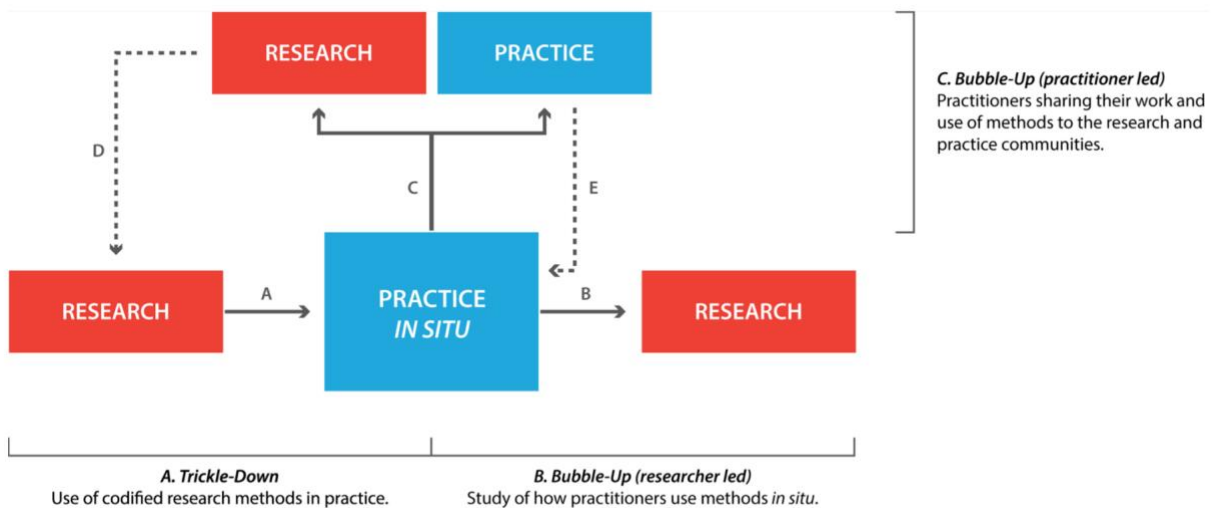
Supporting the point that the research-practice gap is understudied, Gray et al.’s Trickle-Down and Bubble-Up (2014) was the only model of Translational Research in HCI until the start of this dissertation. I also found an influential opinion piece by Don Norman published in the *Interactions* magazine entitled “Translational Developers” (2010), where Norman affirms that “researchers proudly state they are unconcerned with the messy details of design and commercialization,” further mentioning that translating a research product into a product that can be sold profitably in the marketplace is a job for which the research community lacks the skills, patience, or interest. The Trickle-Down and Bubble-Up Model by Gray et al., which is grounded on empirical data, points in an opposite direction than Norman. See Gray et al.’s model in Figure 11 on the next page.

First, Gray et al. explain that “Trickle-down” concerns the adaptation of theory that takes place in design practice, including the use of methods, tools, or concepts that originate in academia. Albeit sparse or unsuccessful, the pervasiveness of translated concepts such as affordances or scenarios points to some form of research-practice translation. Affordances, a concept initially discussed in the Cognitive Sciences in the work of Gibson (1966) and initially used in HCI by Norman (1988), show how HCI scholars themselves often draw on other disciplines to inform their studies. This example serves to remind us that HCI academics themselves often draw from other disciplines such as the Cognitive sciences, Psychology, and Anthropology to inform applied research. Further, many research prototypes and findings born out of HCI research have been translated into real products and services. Such processes can be led by academics-turned-entrepreneurs, through collaborations with HCI practitioners, or solely by HCI practitioners who possess their own translational strategies and do use translations of theories in their work. Chilana et al. (2015) described their collaborations with designers, investors, and users to translate a research prototype into a successful commercial product. How are these practices accounted for by the research-practice gap or the Trickle-Down and Bubble-Up Model?

Second, Bubble-Up concerns the efforts of HCI practitioners—and those of academics as well—to abstract situated knowledge and practice of methods, tools, or concepts into refined theory. Although rare, researchers and designers working in industry may at times publish in academic venues to disseminate findings or methods developed in industry. In turn, practitioners often use academic knowledge

opportunistically, piecing it together and taking it apart, which can turn academic knowledge into richer, situated knowledge. Gray et al. explain that affinity diagramming, for example, is commonly used as a tool to organize and cluster ideas or concepts. It was introduced during the Total Quality Control (TQC) movement in Japan, and although it first became popular in a business context, it was originally known as the KJ Method, which originated as a method for sorting ethnographic data created by Japanese cultural anthropologist Jiro Kawakita. Affinity diagramming eventually found its way to the HCI community, where the procedures for carrying out this method were brought from TQC books, not Kawakita’s anthropological work. Today, affinity diagramming is widely used in HCI research and practice in various digital and analog forms. The image of post-it notes for “affinization” has become ubiquitous in educational, academic, and professional settings.

These examples put forth by Gray et al. and the evidence-based Trickle-Down and Bubble-Up Model point to a more nuanced relationship between research and practice in HCI, although there are many opportunities for more detail.



**Figure 11. Trickle-Down and Bubble-Up Model.**

Yvonne Rogers mentioned that the view of academics as purveyors of knowledge and practitioners as recipients needs to be replaced by a different perspective on the nature of the relationship between them—one that sees HCI research and HCI practice in ongoing dialog. For Koskinen et al. (2011), such dialog could “make research socially robust” (p. 48). Goodman (2011) and Carrol (2013) posit that one of the most significant values of the HCI discipline is integrating science and practice. Other authors have discussed translations between research and practice as negotiations rather than forthright knowledge transferal. For Putnam (2010) and Gray et al. (2014), translation involves the interpretation and reinterpretation of meaning as it is constructed by both the sender and the receiver; practitioners may appropriate theory intentionally or unintentionally—an essential part of using theory and not necessarily a misuse. It alters the view of what it means that a theory is “used” in practice—even though theory is highly formalized, theories may emerge from practitioner use as even richer knowledge. Fox and Rosner (2016) examined the work to bring HCI research back to the people and sites under study, focusing on

HCI's efforts to foster continued dialogue with sites of study. They collaborated with members of their field site to interweave content of a published research paper with local histories of production. For these authors, bringing together the observed contextual practices of professional interaction designers and the communities that are being studied is critical to bridge the gap between HCI research and practitioners.

Interestingly, in HCI, the first instance of Translational Research in the ACM library also relates to Medicine. Lewis and Schimel (2004) were interested in combining advances in anesthetic management and respiratory synchronization with computed tomography (CT) algorithms to produce applications for imaging (CT scanning) of lungs. The term has not seen an uptake in use so far.

### **Summary of Related Work**

In summary, it is worth studying the research-practice gap to better understand how knowledge circulates and is translated across HCI. My analysis of literature suggests important learnings for Translational Research in HCI:

1. It is beneficial to identify the steps and disciplines that can help to harvest the insights of academic scholarship and lead to public gains. Although the metaphor of a research-practice gap is habitually used in HCI, its definition remains unclear and has become a useful and convenient shorthand for a complex problem. In Translational Medicine the concept of multiple gaps between research and practice is generative, as it illustrates the complex, continuous, and interdisciplinary work to transform knowledge into medications, treatments, and care systems. This exemplifies the richness in detail that might be curtailed by the simplicity of the gap metaphor. Therefore, it is important to elucidate definitions, steps and gaps, and models of Translational Research in HCI.

In the first part of this dissertation, I uncover the nuances of Translational Research in HCI, generating a richer understanding of its steps, translations, gaps, and parties.

2. It is beneficial to adopt a user-centered approach to connecting theory and practice where the needs of practitioners are taken into account. Such learning comes from an understanding that translational research intending to persuade practitioners to use scientific output, which at first sight seems to make sense from the perspective of an academic, is insufficient to guide Translational Research. Theory fails to impact practice when it does not have a clear understanding of practitioner context and complex processes of translation and practice. Translational Research must focus on activities beyond the functions to be carried out by the researchers. Therefore, it is important to engage practice and its rich norms and values to build methods and tools that can facilitate Translational Research.

In the second part of this dissertation, I design and evaluate tools tackling specific barriers for knowledge translation based on richer understandings of Translational Research in HCI.

# A Translational Science Model for HCI

As mentioned in Chapter 2, the research-practice gap metaphor may be insufficient to describe the relationships between research and practice in HCI. To make matters worse, HCI lacks other models to describe such a relationship. Therefore, this chapter is an effort to understand how design practitioners and the HCI community as a whole perceive this gap and build meaning around it, as well the day-to-day relationships between research and practice. I examine how knowledge progresses or fails to progress across the HCI field, and I use interviews with a diverse range of members of the HCI community to answer the following question:

*What model for translation describes the translational gaps and activities across HCI?*

In this study, I build on works by Beck and Ekbj (2018) and Gray et al. (2014) which propose that HCI could benefit from different models and metaphors to describe the relationships between research and practice. To do so, I conducted a literature review and interviewed 43 members of the HCI community. Such engagements with literature and firsthand accounts provided the information for the design of a model of how knowledge flows in HCI.

## Methods

I conducted a literature review, interviewed 43 diverse stakeholders in the HCI community, and iteratively designed a model following Zimmerman et al.'s process (2007). The literature review consists of publications on Translational Science, Translational Research, and the research-practice gap in HCI and other applied fields such as Public Health, Management Science, Communication, and Education. In the interviews, I asked participants to define their perceptions of the gap between research and practice, where Translational Work takes place in HCI, and what they have done regarding knowledge translation. All interviews were semi-structured and took from 30 minutes to one hour. Questions changed depending on the area of expertise of the interviewee. Interviews were conducted in-person or via videocall.

I first recruited six HCI scholars from the Seattle area experienced in different activities, such as research, design, community and media outreach, entrepreneurship, teaching, and policymaking to obtain a panorama of translation in HCI and to iterate on the research protocol and preliminary model. In the second interview stage, I broadened the recruiting criteria and interviewed 37 participants from different

locations engaged in specific HCI-related research and practice fields. Participants came from many different traditions such as Computer science, Design, Industrial engineering, Anthropology, English literature, Social Psychology, Interaction, and User experience (UX) Design, Design education, User experience research, and Product Management, working in academia, industry, and government. I also interviewed science communicators and communication managers. Participants had a range of experience in HCI-related fields, and some even did not consider themselves as members of the community, such as communication managers and some design practitioners. Table 4 shows the self-reported percentage of participants with experience in different areas within HCI. “Basic research” experience encompasses research in Social Psychology, Philosophy, and Chemistry. Consequently, experience in basic research did not count towards years of experience in HCI. The bottom of the table shows participant experience in the HCI field. See detailed participant information in the Appendix.

**Table 4. Translational model interview participants.**

<b>Area</b>	<b>Percentage</b>
Design practice	44%
Applied research	42%
Teaching	40%
UX research	26%
Basic research in HCI	21%
Entrepreneurship	21%
Basic research*	16%
Media outreach	14%
Policymaking	7%

<b>Measure</b>	<b>Years in HCI</b>
Median	13
Max	47
Min	1

The development of the model, the literature review findings, and findings from the interviews were interdependent. The model provided keywords for literature searches and framing concepts for the creation of the interview protocol. At the same time, I did not limit my literature review to a predetermined set of keywords; some concepts only emerged from the readings and interviews. I iterated on the model after each interview. After many months, a detailed model emerged from formal data analysis and in-depth critique sessions of designs.

## **Related Work**

Despite acknowledgments of the value of using scientific findings in design practice, studies have repeatedly shown that these insights are rarely adopted (Buie et al. 2010; Remy et al. 2015). As seen in the Background section (Chapter 2), prior work in HCI has primarily described translational processes

using a gap metaphor (Beck and Ekbia 2018). The research-practice gap metaphor is a common concept that represents an undesired space that allegedly exists between the research and the practice of the discipline (Beck and Ekbia 2018; Goodman et al. 2011). Past work has found translational barriers contributing to the gap problematization, inspiring proposals of ways to bridge it (Dalsgaard and Dindler 2014; Goodman et al. 2011; Kolko 2010; Norman 2010; Shneiderman 2016).

However, despite the importance of acknowledging a gap between research and practice (Norman 2010), a gap metaphor might be simplistic and might limit how the HCI field thinks about Translation Science. Beck and Ekbia posited that the gap metaphor influences how HCI researchers set translational problems to focus on barriers, which has implications for the kinds of solutions they seek (2018). Frequently, HCI researchers attempt to bridge the gap by pushing HCI knowledge into practitioner use by presenting research papers in different formats (Gray et al. 2014; Lockton 2013; Remy et al. 2015), in an attempt to make the theoretical insights more pertinent and easier to use for developers (Butler 1985, p. 85). The proposed solutions tackle barriers that HCI researchers and practitioners have identified as reasons for the research-practice gap to exist. For example, recent work has described issues with the terminology and applicability of research papers, how practitioners may lack access to academic resources, and the different cultures and skill sets of researchers and designers (Norman 2010; Reeves n.d.; Roedl and Stolterman 2013).

Countering the focus on barriers, Beck and Ekbia (2018) encouraged the HCI community to focus on the connections and continuities between theory and practice in HCI, suggesting the use of another metaphor—the continuum metaphor—drawing attention to the mutual agreement, harmony, synergy, and support between research and practice. However, how one can think of the HCI Translation Science problem as a continuum is unclear.

Similarly, Gray et al. (2014) have suggested the Trickle-Down and Bubble-Up Model emphasizing that the interaction between the research and practice communities is bidirectional. Bubble-Up describes the efforts of the HCI community to abstract situated knowledge and practice of methods, tools, or concepts into refined theory. “Trickle-Down” describes the way that the adaptation of research and theory takes place in design practice, including the use of methods, tools, or concepts that originate in academia.

Expanding beyond HCI, my literature review shows that “the gap” problem had been the dominant narrative in many other fields, such as Psychology, Nursing, Human Resources, Library Sciences, Management, Education, Social Work, and more (Booth 2003; Carter 2008; Deadrick and Gibson 2007; Biles 1964; Petrucci and Quinlan 2007; Rubio et al. 2010; Rynes 2012; Seymour 2003). Similarly, the gap metaphor is used to describe a disconnect between the research community and the practice community. Common barriers identified in other fields support what is discussed in HCI, including how practitioners are often unaware of the latest scientific findings (Rynes 2012), how practitioners think that scientific research is not applicable to real-world problems (Biles 1964; Seymour et al. 2003) or, if applicable, is too difficult to implement (Booth 2003), and the insularity of academic work dissemination (Carter 2008; Deadrick and Gibson 2007).

In these fields, the work of Everett Rogers on the diffusion of innovations (Rogers 2010) has been incredibly influential. For Rogers, diffusion is the process by which a central source communicates an innovation towards practitioners, among whom the innovation is adopted over time or rejected. Rogers's work is particularly influential in its descriptions of the work of translators to disseminate knowledge and in its measures of knowledge adoption. A major criticism of this work is that it encourages a one-way communication model which is insufficient as knowledge flows through multiple channels in parallel. Also, the centrality of research producers in the model disregards the needs of practitioners and what they have to offer researchers (Robertson et al. 1996).

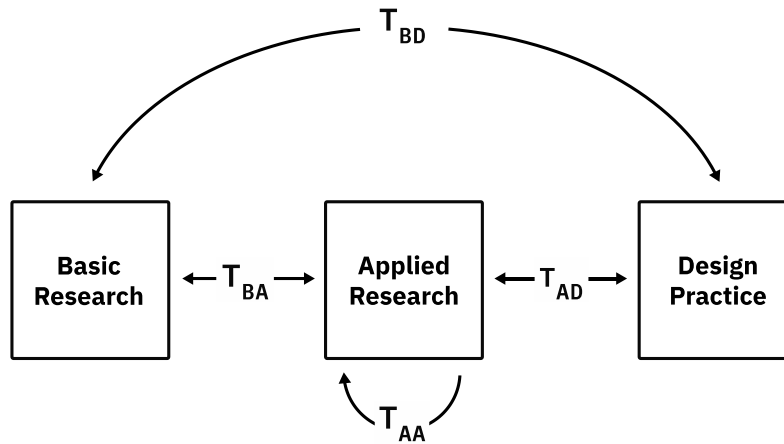
In the early 2010s, similar to Beck and Ekbia's call, the biomedical and health sciences started using a continuum metaphor to describe models (Tabak et al. 2012 specifically encouraged translational researchers to refer to representations of Translational Research collectively as models for simplicity) for the progression of research from basic scientific discovery and proposed human application to clinical treatment (Drolet and Lorenzi 2011). They noted issues with using a single gap to describe such movement between research and practice. Using a single gap had become a source of confusion, as different research steps had differing goals, settings, study designs, investigators, and outcomes (Drolet and Lorenzi 2011). This confusion has hindered the proper identification of translational barriers and prevented proper resource allocation by funding agencies (Woolf 2008).

As seen in Chapter 2, in their review article of the translational continuum in Biomedicine, Drolet and Lorenzi (2011) presented three "translational chasms" (T's or gaps) as the main landmarks in knowledge progression in the translational medicine continuum. This categorization, called the "T-Terminology," is now widely used in those fields. For a longer description of the different T's in translational medicine, refer to the Background chapter.

The most noticeable differences between health and HCI pertain to institutional and policy constraints that need to be addressed to protect drugs and treatment users (Morris et al. 2011; Woolf 2008). Additionally, the continuum model shows the work of many parties to progress knowledge through successive steps, rather than focusing on the work of researchers and clinicians, parties such as basic scientists, applied researchers, marketers, designers, clinical practitioners, physicians, social workers, public health researchers, and policymakers (Drolet and Lorenzi 2011; Tabak et al. 2012; Woolf 2008).

There are drawbacks in using existing models to describe Translational Sciences in HCI, although HCI can learn from them. The Health field models emphasize institutional constraints. The Diffusion Model focuses on disseminating information and does not address the importance of offering applicable resources to practitioners or learning what is useful for them. On the other hand, Health fields show many stakeholders working on a continuum of knowledge progressions, supporting Beck and Ekbia's call (2018). The diffusion of innovation shows how translators disseminate information, resonating with Gray et al.'s work (2014).

In light of the considerations above, how could we in the HCI community rethink the research-practice gap metaphor to represent the HCI disciplines' unique processes of knowledge progression, incorporating learnings from other fields and past work related to Translational Science?



**Figure 12. The Translational Science Model for HCI.**

**Table 5. The steps and gaps of the HCI Translational Science Model.**

Steps	Description	
Basic research	Basic research is performed without thinking of practical ends, resulting in general knowledge to answer a large number of problems, though it may not give a specific answer to any one of them. In HCI, basic research results in the foundational understanding of people, technology, and design. Participants mentioned three main types of basic research relative to HCI: A) research from other fields such as Anthropology and Psychology that is drawn upon to conduct applied research, B) ethnographies conducted within the context of how people use or are impacted by technologies, and C) HCI research probing the technological boundaries, demonstrating new potential interaction capabilities and new experiences made possible by technological advances.	
Applied research	Applied research provides complete answers to practical problems. In HCI, applied research results in practical, goal/solution-oriented research. It is achieved by HCI researchers posing questions through the use of an embodiment of knowledge, the study of interface efficacy and how people relate to it, and the observation of tensions between people and technologies, safety, and ethics in realistic scenarios.	
Design practice	HCI practitioners using HCI and design knowledge to create something new in the “made world.” This involves the deep consideration of specific users, related stakeholders, and technical and market requirements and the integration of art, science, and engineering to make aesthetically functional interfaces.	
Gaps	Barriers	Main translations
T <sub>BA</sub>	Information overload, skillset	Translation of basic science to designs and interactions through an exchange between applied and basic research. Learning and iteration of theories through scientific research processes and communication. Translations of basic research findings into designs to be tested in applied research often occur through a collaboration between basic and applied researchers as well as HCI practitioners.

T <sub>BD</sub>	Understanding, access	Translation of basic science into content that can be consumed more broadly. For example, pop psychology books or events where researchers explain their findings to practitioners.
T <sub>AD</sub>	Applicability	Translation and synthesis of knowledge into usable resources, considering specific application domains. Development of resources that can lead to new knowledge being adopted in design practice.
Bubble- Up	Personal interest, incentives	Looking at practice to inform research. Observation of designs and practice breakdowns as opportunities to inform further investigations. HCI practitioners broadcasting learnings from their day-to-day problem-solving work on social media/publishing platforms.
T <sub>AA</sub>	Information overload, traditions	Dissemination and reuse of HCI research from different traditions.

## Findings

I propose a model for Translational Science in HCI (Figure 12 and Table 5). I ground the decisions that led to the design of the proposed model in my interview findings. First, I present how participants talked about the gap metaphor, Translational Science in the field, and the main actors in Translational Science. Second, I describe how participants view and enact relationships that point to a progression of knowledge between research and practice.

While most participants first described a single gap in Translational Science, upon further reflection, many noted issues with the dichotomy. Initially, participants defined Translational Sciences in HCI as a “BIG gap” or a “barrier” between researchers and designers (P3, P11, P17, P22, P23, P26, P35, P39). Participants mentioned known research-practice barriers such as accessing and understanding scientific work as well as how dissimilar incentive structures could be the biggest drivers for the gap between HCI researchers and design practitioners.

Most participants, regardless of role, agreed that those in the HCI field share the goal of improving products and services for people, even if not directly. Therefore, I set the end-goal of this proposed model as design practice.

In the interviews, participants described their personal experiences related to Translational Science and “the gap.” The roles of additional parties in the progression of HCI knowledge surfaced naturally, including industry researchers, science communicators, as well as a nuanced and fluid variety of academic researchers (e.g., P7 had worked in industry, launched a startup in the past, and now focuses on design research and teaching at her academic department). At the end of the interview, after being prompted to reflect on their own initial interpretations of a single research-practice gap, it became clear to most participants that the gap metaphor is insufficient to describe how multiple parties conduct a series of translations. In addition, most participants, especially HCI researchers, noted their Translational Work falls in the applied research step. This minor, but key, insight revealed through the interviews made

participants realize that the single gap narrative does not distinguish between basic research and applied research.

Based on such reflections, I found evidence to establish that the relationship model between research and practice in HCI is closer to a continuum than to a gap or a unidirectional model, supporting the opinion piece by Beck and Ekbia (2018). Through the analysis of interviews, I found that Translational Science in HCI can be described as a continuum, as various resources and actions are involved in diverse and decentralized progressions of knowledge, advancing knowledge from practice to research and vice versa.

To operationalize the continuum, I used the T-terminology to describe different gaps between steps to facilitate more precise discussions about specific gaps, following Drolet and Lorenzi's model, introduced in the previous chapter (2011).

Drawing from the interviews, the most prominent gaps in the HCI Translational Science Model seem to be between basic and applied research ( $T_{BA}$ ), between applied research and design practice ( $T_{AD}$ ), and between basic research and design practice ( $T_{BD}$ ). I also heard about how Bubble-Up happens, supporting Gray et al (2014), and finally, I heard about gaps within applied research in HCI. Table 5 shows descriptions of the abovementioned steps and gaps with their unique knowledge exchanges, translations, and barriers. Definitions such as basic and applied research were drawn from our data, Shneiderman (2016), and the National Science Foundation (NSF) (n.d.).

As can be seen in Figure 12 and Table 5, the model does not designate where academic or industry researchers reside in the continuum. Basic and applied research can occur both in academic or industry settings, and the same is true for the design of interactive systems (e.g., university startup incubators). Additionally, applied research can be tightly linked to basic research if conducted in an academic setting, but in the industry, it gravitates towards design practice.

As the gap between applied research and design practice is what is often referred to as the research-practice gap, I start by describing the findings related to this particular gap:

#### *T<sub>AD</sub>—Applied Research to Design Practice*

As mentioned earlier in the Methods section, I specifically asked about barriers for communication and translation of knowledge. Most participants, especially practitioners, highlighted that although scientific research communication is obviously not meant to reach practitioners, the applicability of scientific findings might be the most significant barrier keeping applied research from influencing design practice. P7 and P13, experienced in both academia and industry, said that expecting HCI practitioners to read papers is unrealistic. A practitioner noted that designers will not spend the time to read papers:

I don't have four hours to read one paper, I just don't, I could get a lot done in those four hours. Frankly, I do have 10 minutes to skim through a Medium article. (P35)

However unrealistic it might be to expect designers to read papers, designers also do not get actionable information from researchers otherwise (P7, P11, P29, P35).

I have been to CHIplay (...) Very little of what I saw there was applicable, and that event is the only direct contact I have with academia. During the year, everyone is locked up in their companies or universities and don't speak. (P11 runs a virtual reality gaming company)

Many HCI researchers recognized that the long and difficult research process often does not result in actionable resources to be used in design practice, which, in their view, is a problem for HCI (P4, P7, P14, P16, P19, P27, P34).

I then asked participants what translations from applied research to design practice have been successful. Researchers had success with a “make it happen” approach. They described embedding in organizations as consultants or doing design work along with practitioners, first learning what those practitioners care about before offering recommendations (P8, P19, P20, P21, P30, P32), and creating actionable resources for practitioners to use, such as easy-to-use research and design methods, libraries, or open-source projects (P7, P8, P14, P19, P32). P19 told how the idea to create a design method started: “This industry guy asked for resources, and then I asked myself: what do I give to this guy? Papers... and academic research... are too hard for practitioners to get it.” She then studied how to transform empirical data from her published studies into a design method: “Connecting to practice was a study in itself, a long one” (P19)—but she mentioned that this work did not lead to publications.

Compatibility with existing workflows and demonstrated utility affect the adoption of assets and methods by practice, supporting Everett Rogers (2010). Scholars mentioned making assets compatible with current industry practices (P8, P19) and the need for these assets to prove their usefulness from the outset, such as by connecting with metrics that design practitioners value.

I have learned one lesson. Managers and bosses need to want it. They need to be convinced and make that a part of their process. They need to know what the practical outcome of the method for them is. One manager told me: “I will fail if I don't use this method” and that's when I knew I had succeeded. (P19)

### *TBA—Basic to Applied Research*

Basic researchers noted that translating their findings into tools for conducting applied research is complicated and often depends on partnerships, as they lack the “skillset” (P27, P28, P33, P43). Basic researchers may work with HCI researchers or practitioners in joint projects but finding these collaborations can be challenging and costly (P7, P19, P24, P27, P28).

We hired a computer science Ph.D. student who was a really good programmer. We met with him and he prototyped a version that we had in mind. My colleague and I may say “oh let's do this,” not because we know that we have to do it, but because we happened to think

of it, but learning from the programmer that would be difficult to implement, we would think of something else.” (P27)

P27 and P33 emphasized that collaborations with students or designers are temporary and expensive. In P27’s case, the student soon graduated and left only the code, which put the project on hold for a year. P27 and P33, who are self-described basic researchers, even started learning design and engineering skills to do applied research on their own.

Second, basic researchers think that engaging with diverse scholarship allows them to do work that is “new” and “fresh” (P5, P17, P26, P28, P30). While it can be difficult to quickly grasp other research traditions, there is institutional support through citations and a common understanding of papers as output. Interestingly, few HCI scholars mentioned being incentivized to participate in communities of interest that are peripheral to HCI, which for P28, P29, and P35, “stifles research innovation.” It seems like most of the knowledge circulation in HCI happens within the confines of the CHI community and other Association of Computing Machinery (ACM) conferences.

HCI researchers also said their work rarely feeds back into the original bodies of theory from which they draw on.

I draw on social psychology theories and behavior change and translate that into designs. So that’s a translation. Usually, you’re drawing on many different theories to help inform one coherent thing. Not the opposite. I don’t feel like I contribute to basic science. (P7)

Participants again mentioned a “citation deficit” as evidence for the basic-applied research gap (P3, P14). In the interviews, there was no mention of efforts to facilitate engagement with other disciplines, or to promote more—and more relevant—citation exchanges across disciplines.

### *T<sub>AA</sub>—Gap within Applied Research*

While some participants who frequently participate and publish at the CHI conference boasted that it is common to learn from and build on diverse work (P1, P7, P19, P27, P32), others mentioned a critical barrier related to citations, the dominant currency in academia.

The reasons given by participants for the citation failure were information overload and academic traditions. Participants mentioned that it is difficult to keep up with all publications within an area of studies (P1, P9, P15, P17, P32, P43), which is curious, as most of the knowledge circulation happens within a few well-known venues. Although curious, this observation is nonetheless real and relevant. As much as academics have a general idea of what is being researched in the field, through publications and presentations in major journals and conferences, it is extremely difficult to keep up with all advancements. Still, some researchers said that certain authors can devalue ethnographies or systems design if they do not engage with it, which can cause those authors to not learn from or cite work (P4, P5, P19, P27). Even within subcommunities, research papers often do not get cited:

I speak directly to those issues. We use the same keywords, publish in the same venues. It becomes a personal grudge, which is a problem within HCI. You may not like my work, but it should be cited. If you disagree with my approach or findings, cite it and explain why. (P2)

### *T<sub>BD</sub>—Basic Research to Design Practice*

Participants initially marked this as the rarest translational path, as basic researchers do not plan studies or write papers to influence practice. For P6, P17, P24, and P33, T<sub>BD</sub> is where the understanding and access barriers are more salient. P19 mentioned that “HCI is so important because it sits in between Basic research and Design practice to do the translation.” Although rare, participants said that basic research can influence design practice in different ways: pop psychology books (Ariely 2008; Eyal 2014) are often written by practitioners with scientific training, sharing theory blended with personal industry experience and often partnering with scholars; outreach such as participating in radio talks and contributing to scientific communication (P6, P17, P24); disseminating findings to targeted groups of practitioners searching for new knowledge to inform their practice; in discussions (P4, P8, P17, P30, P33); and in events (P24, P43). Finally, training in basic research affords the abilities to work with practitioners through research method skills and deep scientific understanding (P6, P17, P24, P28, P33, P40, P43).

### *Bubble-Up*

Participants who engaged in Bubble-Up work described researcher-led strategies to draw on practitioner knowledge. For P15,

It is crucial for researchers to really engage with practitioners and know how things are done in industry. This is, or should be, the minimum requirement to contribute to design.

HCI researchers interested in learning insights from practice put effort into a few strategies that they deem successful, such as organizing and attending practitioner-oriented conferences (P9, P13, P15, P24), keeping track of students who go on to leading industry positions (P13, P29, P31), and using online design groups:

I’m part of Facebook and Slack groups to talk to practitioners. Most of the times we talk about new tools or books, design trends, but sometimes deeper issues and methods. It’s very varied but focused on practice only. It’s almost like a crowdsourced design encyclopedia on current topics. (P15)

Design practitioners mentioned not actively engaging with Bubble-Up mostly because of intellectual property restrictions of the companies where they work (P12, P35). In turn, disseminating carefully vetted case studies in platforms such as Medium has become common, and participants mentioned an interest in doing so for personal branding (P29, P39, P41, P42). Interestingly, I heard from all HCI practitioners that instructors with professional experience as designers or engineers effectively made the “academia-

industry linkage” (P35), bringing knowledge from practice into the classroom. This view was consistent among HCI professors with industry experience (P10, P11, P13, P15, P34, P35, P38).

The Bubble-Up goals that participants mentioned were to learn what practitioners care about (P9, P13, P15, P24), to gain insights about design field trends (P13, P29, P31), and to improve teaching (P15) and syllabi (P13).

### *Different Translators and Translational Work*

Through the interviews, I uncovered different types of translations that address Translational Science barriers: the design of example products, people transfer, and science communication.

*Synthesizing information into contextualized products.* This type of translation, achieved through the collaborative work of basic researchers, applied researchers, and designers, can entail both translating basic knowledge into research concepts for testing and applied research into prototypes and guidelines that can facilitate adoption in design practice.

In the interviews, I heard specific instances of Translational Work altering the original research insight to create a new product to address more contextualized problems. Both in  $T_{BA}$  and in  $T_{AD}$ , knowledge can get lost in translation because of the synthetic nature of design, which is reflected in the accounts of basic and applied researchers who have engaged in translations (P8, P19, P24). P24 mentioned that a foray into applied research required making many concessions and changing their initial ideas because of technical and design constraints. P19 in turn mentioned the need to make a design method compatible with industry practices, which required drastic adaptations.

The challenge in translating research into products or methods is described by Chilana et al. through the creation of a new venture born out of HCI research focusing on adoption (2015) and by the concept of appropriation used by Gray et al. (2014). As seen in the previous paragraph, not only do HCI practitioners appropriate knowledge, so do researchers when attempting to bridge gaps.

*People transfer as knowledge transfer.* Chilana et al.’s migration from academia to starting a venture (2015) represents a second path that drives translations: the movement of people. People move across gaps and steps, such as students or professors working in industry temporarily through sabbaticals, collaborative projects, or consulting permanently after graduating or after a career change. People carry knowledge and skills with them. Most participants mentioned that industry researchers, for example, whether trained in applied or basic research, can help translate the terminology of academic contributions (both in  $T_{BD}$  and  $T_{AD}$ ). I interviewed industry researchers with academic training who shared how they have used academic research to inform their work. First, industry researchers said that, most commonly, their knowledge of research methods is employed on a day-to-day basis. Second, they use scientific findings to inform the creation of study protocols and initial product design directions. In these two latter cases, industry researchers benefit from their academic experience in reading and conducting scientific studies to quickly evaluate and identify takeaways in existing bodies of knowledge, contextualizing that

knowledge to the problems that their companies face for the design of products or services (P12, P16, P17, P40, P42).

Furthermore, most participants called out one particular form of people transfer—education—as perhaps the most common path for HCI to influence design practice. Academia usually contributes to society with research findings, but HCI researchers in academia also participate in the training of practitioners. Multiple HCI professors mentioned that teaching HCI theory in classes is challenging and that how to do so effectively is an open question. “How do we effectively train people to be sensitive and make them think about these questions [referring to information privacy and persuasive design] when they go into the workforce?” (P1).

*Formal and informal science communication.* While papers are a primary communication artifact among researchers, time constraints hinder their use by industry researchers. To bridge  $T_{AD}$  and  $T_{BD}$  gaps, generating curated resources is particularly important (P6, P12, P16, P20, P34 P42). “I have time to read the abstract basically. I’d love to read more academic papers, but everything is due yesterday in industry” (P12). Participants valued Nielsen reports (P12, P20, P34) and meetings with scholars (P21, P40, P43) for helping them learn about the latest relevant readings in a particular area.

Writing books, blog posts, presenting research in events, talks, or informal conversations can also help bridge gaps. Science communication can be done by writers, researchers themselves, or collaboratively. Participants saw it as an important pathway to reach and influence scholars, practitioners, and public opinion (P1, P6, P7, P22, P23, P25), supporting findings from Smith et al. (2018). There is also a more informal approach to science communication in which industry researchers use academic research opportunistically in discussions with their product teams, or when academic researchers engage in casual conversations with design practitioners about how academic research can inform product development.

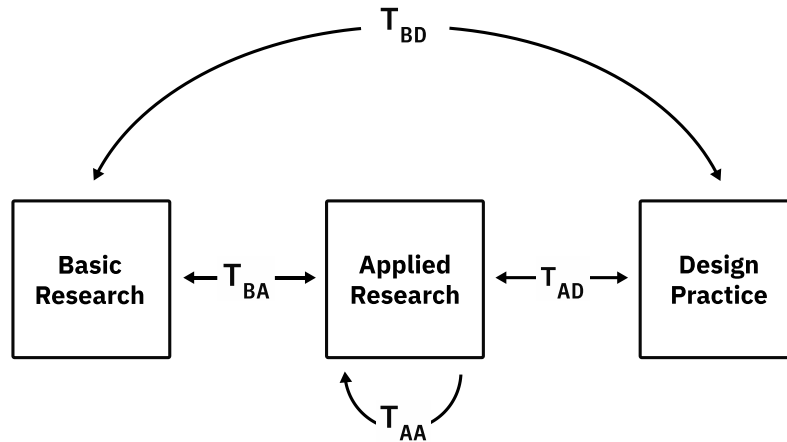
In science communication, a major barrier is balancing scientific precision with writing content that appeals to specific audiences. HCI practitioners reported difficulty reading research papers (P12, P20, P21, P35, P37, P38). For the three science communicators I interviewed (P22, P23, P25), the most significant issue in working with scholars is their difficulty in explaining things simply. P25 said that academics dislike having their work translated, “because they want the original language in the final piece.” HCI scholars acknowledged this barrier and mentioned a struggle in balancing simple communication and scientific precision. P1 has written blog posts and mentioned that it is hard to break away from the academic writing style:

Academics tend to be very fact-driven, and we have a certain style of writing, and we get this feedback—you have to be friendlier, you have to insert fun pieces, it’s just a different style of writing to make it an engaging piece. So even if the desire is there, the ability sometimes can be difficult. We are more precise and nuanced in the way we describe things.

P7 adds that she has hesitated to forego precision because study results are not entirely generalizable to all populations.

## Discussion

I compared literature from different applied fields with firsthand accounts of a variety of stakeholders in the HCI community. This triangulation allowed me to provide a more nuanced view of the translational mechanisms and barriers currently at play in the HCI community. Such a nuanced view was built into how I designed the model of Translational Science for HCI. In this section, I discuss the implications of a more nuanced view of Translational Research in the HCI community.



**Figure 13. The Translational Science Model for HCI.**

### *The Value of a Translational Science Model for HCI*

The model I propose (Figure 13) draws on the metaphor of a “continuum” rather than a “gap.” Consistent with Beck and Ekbja’s (2018) position paper, my study shows that various resources and actions are involved in a progression of knowledge via multiple steps, advancing scientific discoveries towards design practice and practice discoveries back to academia. Of course, there are challenges in this knowledge progression, but they do not qualify as a single gap, as the research-practice gap metaphor reinforces.

Similarly, Translational Medicine researchers Tabak et al. (2012) and Woolf (2008) claimed based on their experience and investigations that Translational Science models can make translational research more successful, as they distinguish the different gaps, steps, translations, and disseminations.

I highlight two main benefits of the HCI Translational Science Model: a) repositioning translational barriers into a more specific arrangement, helping to understand where translation occurs or has stalled, and B) supporting discussions about allocation of resources that facilitate Translational Science.

First, HCI scholars doing research on Translational Science may describe the aim of their research more clearly with the proposed terms, while helping to refine model constructs. For example, the model may be used to describe where research has progressed or stalled (e.g., the use of design applications

found in HCI research is delayed in  $T_{AD}$ ), allowing the study of specific translational barriers at play. In this context, I specify nuanced barriers and offer additional insights into how to address them. For example, publishing academic papers to broadcast findings within the scientific community is still important. It is not, however—and should not be—a functional communication channel between research and practice (Dourish 2006). The model highlights that applicability is the most significant barrier for HCI research to influence design practice ( $T_{AD}$ ). Instead of working on new framings of design implications, the HCI community might focus on tools that both take into account practitioner context, and also make it easier for practitioners to apply HCI findings.

Second, the model can help understand areas where structural support is needed. Funding agencies and universities are essential pieces of Translational Science in HCI (Chilana et al. 2015; Koskinen et al. 2011), as they help drive and support research with broad social and economic implications (Dachtera et al. 2014). The model can help organizations more precisely target steps and barriers where vital advances are stalled and catalyze work that can facilitate translation. For example, with a more specific Translational Science model, the health field devised initiatives such as dedicated budgets, research centers, scientific journals, and conferences for different T's (Collins 2011; Dearing and Kee 2012; Woolf 2008). While I do not argue that all of the initiatives listed above are necessary for more a robust Translational Science in HCI, they should at least be considered. Foremost, investment in the translation of basic and applied research for use in design practice is vital for capitalizing on investments in producing new insights. An excellent example is a specific project that emerged in the health domain context: a plan to reduce cancer mortality by 2025, consisting of concentrating translational research in a few centers that can vet and test scientific finding clusters with the most potential (Cheever et al. 2019).

### *Different Translators and Translational Work*

The constellation of parties involved in translating HCI knowledge is broader than just the subcommunities of HCI researchers and design practitioners. I found that these parties do cooperate and transition across steps and gaps. Based on my findings and the results of previous Special Interest Groups (SIG's) (Buie et al. 2010; Reeves n.d.), rather than creating a new profession (Norman 2010), I believe there is a need to leverage and coordinate the incredibly diverse and capable parties already somehow involved in Translational Science efforts, especially those who can—and want to—do more Translational Work (while explaining the value of doing so to others who could become translators). In the following pages, I address efforts that, in addition to the findings presented in the previous sections, hold promise as effective channels to strengthen Translational Science in HCI and should be developed or further studied.

First, the scientific publication cycle helps bridge Basic Researchg and Applied Research as the  $T_{BA}$  gap suffers less with understanding barriers. My work suggests that scientific findings could be clustered and communicated across fields to ensure that knowledge progresses throughout the Translational Science Model. To accomplish this, existing infrastructure can be leveraged and expanded upon, such as crowdsourced sites for summarizing published research (such as scholar.stanford.edu) and perhaps new ways to aggregate and discover knowledge clusters on Google Scholar and other academic work search engines (scholar.google.com, academia.edu, researchgate.net).

The model also highlights an intracommunity gap that needs to be considered. The  $T_{AA}$  gap raises concerns about fragmentation within the HCI academic community. As the HCI community grows, it is essential to encourage learning about, engaging with, and citing research across application areas and ways of knowing.

In  $T_{BD}$  and  $T_{AD}$ , translators such as science communicators and industry researchers help to share curated academic knowledge with design practitioners, similar to what Everett Rogers described as change agents (2010). HCI practitioners already use social media sites such as Reddit and Medium to publish and discuss prominent issues. For example, the /r/userexperience Reddit community provides a venue for more than 32,000 UX amateurs and professionals to communicate (Kou and Gray 2018), and 293,000 users follow the UX Collective Medium publication (as of October 2019).

One other dissemination pathway is the education of students and researchers on the complexities of translating scientific findings. A key question for education is whether current HCI education is sufficient or if the community should train new kinds of translators or develop translation resources for existing translators in other fields. While Norman proposed the training of translational developers (2010), the model suggests that different skills and training may be needed to prepare people who will help bridge each distinct gap. The HCI field could potentially train many translators and must consider this diversity of skills and roles in training for Translational Science.

In  $T_{AD}$  specifically, HCI has the opportunity to translate research results into resources that practitioners can use. HCI scientific findings are usually shared through papers which introduce and enforce the applicability barrier, as products of the research process are often not ready for immediate use by practitioners (Bero et al. 1998; Wandersman et al. 2008) and rarely consider the practicalities of everyday design practice (Gray et al. 2014). The literature describes many different tools that can help communicate research findings, such as training modules, workshops, technical support, and guides (Fixsen et al. 2005; Tabak et al. 2012). In HCI specifically, many vehicles for HCI knowledge have been proposed but should be more systematically evaluated (Beck and Ekbj 2018), such as strong concepts (Höök and Löwgren 2012), different instantiations of design patterns (Alexander 1977), scenarios (Carroll 1995), personas (Cooper et al. 2014), conceptual models (Norman 1986), design concepts (Sas et al. 2014), design heuristics (Dix et al. 2003), research objects (Odom et al. 2017), design fiction (Wong et al. 2017), tutorials (Desjardins et al. 2017), methods (Gray et al. 2014), and assets (Colusso et al. 2017).

### *Must HCI Measure Knowledge Adoption?*

Describing the process of adopting and adapting HCI research to practice, Chilana et al. (2015) asked whether studying knowledge adoption is beyond the scope of HCI. I believe that there is a need to explore what it means for an HCI contribution to be adopted beyond prototypes (Goodman et al. 2015), mining research insights, and translating them into practical, evidence-based resources to support HCI practitioners (Norman 2010; Rogers 2004). Designing evaluations of knowledge adoption could bring empirical value to the design field. The findings support this approach by suggesting that tackling the applicability barrier in  $T_{AD}$  to facilitate the adoption and application of knowledge is necessary. Here,

there are many obvious strands of work in the intersection of T<sub>AD</sub> with diffusion of innovation studies and knowledge adoption at individual and organizational levels (Rogers 2010), as well as many relatable user-centered methods for aligning user needs with business needs (Chilana et al. 2015). However, Chilana et al. argue that there is currently little incentive for HCI scholars to invest more time and resources in understanding adoption. If a researcher aims at influencing design practice—to bridge from T<sub>BD</sub> or T<sub>AD</sub>—then evaluating knowledge adoption (Lindley 2017) may be necessary to know whether one has succeeded.

*Engaging—And Studying Engagement—With Translators*

HCI must continue to engage with everyday successes and problems that practitioners face in their work. An effective feedback loop in Translational Science helps keep applied fields grounded in, and relevant for, practice. For example, asking questions such as “Is this privacy recommendation found in a CHI conference paper effective or used/adapted in different ways in practice?” Research with a focus on professional design practices allows insight into how practitioners refine and concretize abstract knowledge (Gray et al. 2014; Lallemand 2015). Previous work provides guidance for the *in-situ* study of professional design practice (Goodman et al. 2011) or the use of social media traces to learn about design practice (Kow and Gray 2018).

While the examples shown in the previous paragraphs focus on sharing knowledge with design practitioners, they are only one role in Translational Science in HCI. Shneiderman (2016) advocated for building the capacity to collaborate and coordinate with many stakeholders, blending scientists, engineers, designers, and end-users to produce higher-impact research converging into a solution. I was impressed by the many original and creative translations that the diverse HCI community, represented through the 43 participants and referenced authors, has found to bridge and study research and practice in HCI. Future work should strive to understand the barriers to, and effective strategies for, engaging the range of stakeholders in Translational Science for HCI (see Table 6).

**Table 6. Additional translators that can facilitate Translational Research in HCI.**

Translators	Evidence
Policymakers	Mentioned by participants as a growing and effective role for regulating practice (P1, P3, P7, P26). Policymakers have a need for facts based on the best knowledge currently available (Weiss 1995). Lazar (2017) even affirms that, for example, for accessibility researchers to have any real impact outside of the research community, they need to understand law and work with policymakers.
Professional associations	UXPA (User Experience Professionals Association) or IxDA (Interaction Design Association) for example, are organizations that frequently set up local events for the HCI community. Participants believe that a stronger link with these associations can help establish interfaces between researchers and practitioners. Researchers have partnered with meetup groups and professional bodies to organize events combining academic and industry talks (Colusso et al. 2017), but practitioners rarely meet with researchers at these

events (Norman 2010, Stolterman 2008), and it is unclear how effective they are at supporting the adoption of HCI knowledge.

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Business stakeholders	Business-related stakeholders, such as marketing, financing, and venture capital. There is an understudied pathway in turning academic research into commercial products and services, a path documented in Chilana et al. (2015) and mentioned by a few participants in this study (P1, P3, P7, P8, P13, P15, P17).
Society, end-users	Some HCI researchers said that they are interested not in influencing design practice, but in working directly with the populations that can benefit from their work (P5, P8). Ladner points to working with end-users to tackle their problems through an open-science approach as an alternative (Ladner 2014). Some participants also mentioned working with the media to influence public opinion. This way, users would demand change from companies (P1, P7, P43).
Funding agencies	Top-down stimuli can promote structural change and reorganize infrastructures to facilitate Translational Science. More work about—and with—decision-makers of funding agencies is necessary.

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## Summary of Contributions

In this chapter, I presented a qualitative study of the nuanced knowledge exchanges that happen across the HCI community. As a result of interviews and an extensive literature review, I proposed a model based on the idea of a continuum (Beck and Ekbja 2018) to represent how HCI knowledge flows between multiple stakeholders. In the continuum, I describe multiple steps and gaps between basic and applied research, and design practice. I also identified multiple translators and the specific Translational Work they do. The proposed model offers insights into how to bridge translational gaps and how to work with and train translators effectively. This model can act as a foundation for future research on Translational Science in HCI.

## Translational Resources to Support Design Practice

In this chapter, I examine how different types of information can find their way into the work of HCI practitioners. I zoom in to the end-point area of the Translational Science Model for HCI (Figure 14), where HCI practice resides. Such an area is most commonly thought about in HCI as the general “research-practice gap.” Although my approach encompasses both  $T_{BD}$  and  $T_{AD}$ , I used a grounded approach focused on practitioners who may not perceive specific differences in research or informational resources’ origins. I asked, “What resources do HCI practitioners use to inform their work? How do HCI practitioners use these resources?”

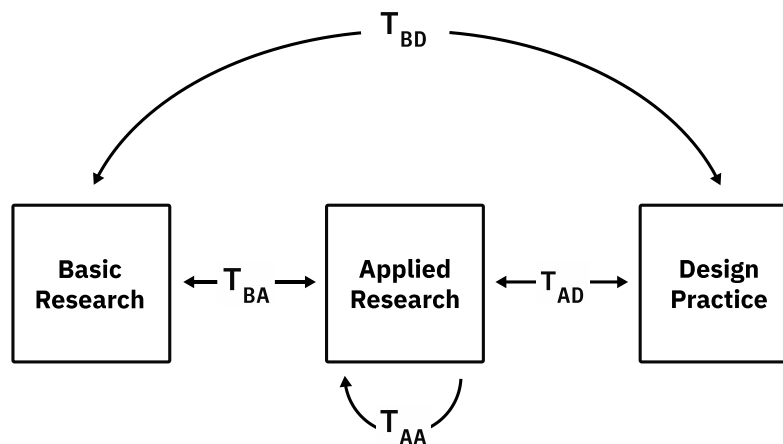


Figure 14. The Translational Science Model for HCI.

As a response to the HCI academic community’s continued focus on creating theory-driven resources to inform design practice (Remy et al. 2015; Grosse-Hering et al. 2013; Lockton 2014), I used a practitioners-first approach to investigate what resources designers already consume and how resources are used to inform design practice. This interview study also detailed the barriers that keep design practitioners from using academic research findings. I specifically examined how academic and

nonacademic information resources support, or fail to support, practitioners' work and what makes informational resources useful to practitioners.

In interviews, I asked 22 professional design practitioners to describe the information resources they use to support their work and what barriers they perceive to using academic research. I also asked practitioners to evaluate existing theory-driven design cards (Artefact 2016; Lockton 2013) and claims (Kraut and Resnick et al. 2012). Find more details on the study methods and recruiting criteria in the Methods section in this chapter.

I offer three high-level contributions: a) a detailed catalog of barriers that inhibit the use of academic resources in industry, b) a list of resources that practitioners use to support design activities where translational resources can be beneficial, and c) recommendations for the design of translational resources that can be useful for practitioners. Such findings could inform the design of translational tools to support research communication, taking into account design practitioners' informational needs and values.

## **Related Work**

Academics in the HCI community have long sought to support the work of practitioners with research findings. A sign of this intention is that many HCI papers contain design implications in discussion sections, which intend to translate scientific findings into principles that can be used in design practice. As much as design implications summarize potential applications of research findings, academics have demonstrated that it is difficult for practitioners to understand and use them (Buie et al. 2013; Dourish 2016; Geldof and Vandermeulen 2007; Norman 2010). In addition, because many papers present design implications that have yet to be empirically evaluated (Sas et al. 2014), designers may not be confident in them as implications may lack key implementation details that practitioners need. As a result, the current form of design implications in academic papers is not enough to drive the appropriation of academic results in industry (Buie et al. 2013; Geldof and Vandermeulen 2007; SIGCHI n.d.).

As a response, the HCI community has been experimenting with books, blogs, and other representations to communicate their work.

Kraut and Resnick et al.'s 2012 book, *Building Successful Online Communities*, for example, describes a set of actionable design claims backed by details about the scientific methods, applications, and results that informed the claims. Readers can quickly scan the book pages to find design claims, as they are clearly highlighted. However, these claims are still very much like those found in academic papers (Figure 16).

Academics and practitioners have created representations of theories using cards (Figure 15) (Artefact n.d.; Friedman et al. 2011; Grosse-Hering et al. 2013; Lockton 2013). These cards contain theory-driven insights framed as solutions to a problem in a context. Cards describe the problem, its solution, where this solution has been found to work, a short design rationale, and visual examples. Studies find issues with cards, especially regarding applicability and content. First, theory may affect the design process in unpredictable ways, which raises questions about the applicability of academic recommendations (Grosse-Hering et al. 2013; Norman 2010; Remy et al. 2015). Also, the card format constrains the amount

of evidence and rationale provided to practitioners, which can hinder application. However, even when patterns contain further evidence and rationale, designers have difficulty understanding how to use the cards (Grosse-Hering et al. 2013; Remy et al. 2015).



Figure 15. Example of design pattern cards.

Design Claim 9 Requests from high-status people in the community lead to more contribution than anonymous requests or requests from low-status members.

Design Claim 10 People are more likely to comply with requests the more they like the requester.

Figure 16. Design claims from *Building Successful Online Communities*.

Therefore, it is still unclear how to effectively communicate academic research findings through design recommendations that work for practitioners.

Additionally, it is unclear if and how translational resources created and disseminated by academics in HCI are accessed and used in practice. Designers may indirectly access theory through other channels rather than academic resources (i.e., design and psychology books, blogs, online communities, and other practitioners, often coworkers). These channels all frame design recommendations differently. A designer

may read a psychology book or reference an existing product or a research prototype, but how do these different resources help translate theory to the designer's practice, or how could they?

These considerations bring us back to the chapter's research questions: Do designers use resources generated by academic researchers? If so, how? If not, why? What resources other than academic research do designers use? Why and how are they used?

## **Methods**

I interviewed 22 industry designers recruited through online communities including User Experience and Technology Meetup groups and local designers' Slack channels. Participants varied in their job titles, educational backgrounds, industries, and experience and worked for small and large companies (Table 7). Recruitment was skewed towards designers of desktop or mobile applications due to the prevalence of such roles in the local Seattle design community.

I asked practitioners to: a) describe a recent project, b) describe the information resources they use to support their work, and c) evaluate the usefulness of design pattern cards as well as Kraut and Resnick et al.'s (2012) design claims. See examples of design cards and design claims in Figure 15 and Figure 16. I asked participants how useful the cards and claims were as resources to inform the design process and what else the cards would need to become useful resources for design.

Each interview was audio-recorded and transcribed. As a preliminary analysis effort, three researchers from my research group used open coding to identify themes in sample transcripts in an affinity diagramming session. In a second step, two researchers followed an iterative axial coding process to understand relationships among emerging concepts (Strauss and Corbin 1998).

In addition, I used member checking (Lincoln and Guba 1985) to validate my findings and to improve accuracy and depth. In this stage, I interviewed four practitioners from organizations that make use of both academic and user research. These practitioners were directly recruited by the research team, drawing on personal connections in the industry. Prior to this last round of interviews, I asked the four member-checking participants to read the preliminary recommendations garnered from the first round of interviews. Participants challenged and elaborated on findings and provided suggestions to refine the results.

Table 7 shows the self-reported job titles, industries, and experience of my participants. Above the double-line on the table is a list of participants from the interview phase. Below the double-line is information on the member-checking participants. For more detailed information on participants, refer to the Appendix.

**Table 7. Practitioner interviews.**

<b>Participant #</b>	<b>Job title</b>	<b>Industry</b>	<b>Experience</b>
<b>Interviews</b>			
P1	UX Designer	Consumer Electronics	5
P2	UX Designer	Agency	4
P3	Interaction Designer	Agency	3
P4	Visual Designer	Agency	4
P5	Visual Designer	Freelancer (Entertainment)	20
P6	Lead UX Designer	Retail	7
P7	UX Designer	Agency	5
P8	Design Technologist	Consumer Electronics	4
P9	Interaction Designer	Search Engine	3
P10	Game Designer	Virtual Reality	8
P11	UX/UI Designer	Agency	3
P12	UX Design Director	Finance	5
P13	Technologist	Games	4
P14	Senior UX Designer	Energy	2
P15	UX Researcher	Business Analytics	9
P16	UX Designer	Marketing	9
P17	Senior UX Designer	Health	8
P18	UX Designer	Education	1
<b>Member checking</b>			
M19	Product Designer	Advertising	7
M20	Product Designer	Virtual Reality	5
M21	Design Manager	Social Networking	14
M22	User Researcher	Videos	3

## Findings

In this section, I report on the results of interviews and member checking. I obtained an overview of the resources that design practitioners use instead of theory. Importantly, I also replicated past work describing barriers for how theory-driven resources can inform the work of practitioners (T<sub>BD</sub> and T<sub>AD</sub>) and added more detail into why they occur.

### *Perceived Barriers for the Use of Scientific Research in Design Practice*

Practitioners value insights from domain expert researchers (P3, P10, P14), especially when researchers study topics that overlap with practitioners' work and interests, such as Behavioral psychology or virtual reality (P5, P14, P10). However, only two designers (P14, P18) mentioned using peer-reviewed research. Based on the interviews, I present three difficulties, or barriers that prevent designers from using academic research in the design process.

**Difficult to read.** Certain language undermines practitioners' ability to understand, and their interest in reading, academic research. "When I think of research, I think I'm going to have to slowly go through tons of reading with big vocabulary words, because someone wanted to sound smart" (P3). Practitioners find reading academic research boring (P1, P7, P8, P11, M20)—"It can be kind of dry, it's scientific knowledge, it's not meant to be entertaining" (P11).

**Difficult to access.** Designers use different vocabulary than academic researchers, hampering the search of academic resources (P7, P13, P16, P17).

I don't know what I don't know. I lack the vocabulary to find that very specific field in literature. Often they have very specific names and the literature has all been authored with that knowledge built in. (P13)

Practitioners did use academic resources when someone pointed them toward useful pieces (P5, P13, P18, M22), at school (P1, P8, P14, P18), when a manager asked on behalf of a client (P3), or when a friend in academia presented a paper or a thesis (P5). However, access is often restricted to subscribed organizations.

It requires me to have some kind of membership to it and that's a cost. It costs thousands of dollars to get access to, and our company just doesn't have much money to blow. (P14)

Also, with limited access to online publishers and limited referrals to new papers, designers' personal libraries of academic resources may stagnate once they leave school or a company. To work around these access issues, designers may ask friends from academia to download academic papers and to digest the academic lingo (P7, P11, P13, P14).

**Difficult to apply.** Practitioners said academic resources are not "to the point" or "actionable" (P1, P3, P16).

The whole idea [of using academic research] just seems like a waste of time when I can google something, and then get tons of well written articles that are visual, fun to read and actionable. (P3)

Practitioners said academic research goes past the associations they have with a design space and that researchers dislike making clear, simple recommendations, which is what designers want (P16, M21).

Academic research goes so deep that it no longer is applicable for us [designers]. Everything is pure theory and the real world doesn't work that way. What happens is, when you get into the real world, there's a culture shock of people not thinking that you're a genius, and that your crazy school theory isn't applicable to this product. I think that in this sense academics are doing a disservice to the community by being too general...and not actionable. (P5)

For practitioners, academics do not care about important design contexts such as resource constraints and contentious stakeholder situations or making design decisions on top of legacy structures, for example (P1, P3, P6, P7, P13, P16, M19, M21).

I think academics do research for a different purpose. They're trying to solve their own problems, graduate or get tenure. It wasn't intended for us [designers]. (P7)

Designers emphasize that information resources need to be actionable and increase their productivity: "People who do real-world problem-solving need design patterns to work faster and collect paychecks." (P17). They often mentioned easy-to-use, "plug-and-play" design patterns such as User Interface templates and icon kits.

### *A Taxonomy of Resources Used by Designers to Inform Different Design Activities*

Instead of academic research, design practitioners used other resources to inform different steps of their work. I created a taxonomy and organized resources that designers use under the design activities of understanding, brainstorming, building, and advocating (Table 8). The taxonomy helps to categorize resources so that we can more easily communicate which design activity is informed by which resource, as there is a diversity of design processes and types of information used by practitioners.

Practitioners described using examples to support different design activities: models for understanding a design space, visual examples for brainstorming, interactive examples for building, and data for advocating. Advocating occurs throughout all design activities. Resources highlighted with an asterisk in Table 8 were the most used by designers in our study.

**Table 8. Resources that designers use to inform discrete design activities.**

Activity	Resources that Support this Activity Example Resources
<b>Understanding</b> Build foundational knowledge of how to approach a design challenge	<b>Models</b> Contextual user research,* books, articles* <hr/> Others' Experiences Reputable case studies on Medium.com posts,* Nielsen Norman Group articles, recognized experts or similar others on Slack.com channels, Reddit, Reddit.com Ask Me Anything (AMA) sessions
<b>Brainstorming</b> Generate ideas of possible directions to tackle a design challenge	Understanding Resources User research data, resources generated by designers in Understanding <hr/> Design Examples Dribbble.com,* Google Images,* Behance.com,* Pinterest.com,* Ideation cards, science fiction books, pop psychology books, design books
<b>Building</b> Move from a preliminary idea into product development through prototyping or detailed design	Libraries UI libraries,* books, blog posts <hr/> Existing Apps Apple's App Store, Google Play App store, ProductHunt.com <hr/> Forum-Based Websites StackExchange.com, StackOverflow.com, Quora.com
<b>Advocating</b> Explaining design rationale	Evidence for Idea or Chosen Solution User research, trusted resources, academic research

**Understanding.** A key design activity is understanding the design challenge at hand. Practitioners described using models to articulate what is expected to be accomplished and how: visual representations of user mental models and reading the experiences of other designers. Designers develop mental model representations from user research or from nonacademic resources. If the company where they work invests in user research, practitioners develop their own models of how users think or perform tasks (P1, P17, M19). If their organization does not conduct user research, design practitioners find visual representations of mental models in resources describing human behavior and cognition such as blog posts or “pop psych” books.



**Figure 17. Representation of movie fans' mental model.**

Creating models such as the one from Young (2008) in Figure 17 makes it easier to engage with users' context, motivations, and thought processes (P9, P13, P16, P17, M21). While it may be difficult to present the nuances of theoretical contributions visually, academics could show complex information in a more digestible manner. For example, ethnographers often illustrate research sites using such methods as architectural details, blueprints, navigation activity, and videos (Dourish 2006).

**Brainstorming.** During brainstorming, practitioners ideated several ways to address a design challenge (P1, P5, P6, P10, P16). Practitioners used visual representations, including resources created or identified in the understanding design activity, to support their individual and team brainstorming activities. Examples found in online galleries such as Dribbble, Pinterest, Behance, and Google Images often help designers to brainstorm potential solutions (P1, P2, P11). Although designers enjoy searching for visual inspiration in gallery sites, the search experience is scattered and can be overwhelming (P1, P3, P8, P10). Also, the lack of context makes it hard to assess whether a resource should be used and how (P1, P8, P9, P16, P17).

The inspiration that I find on Dribbble is nice to have (...) They post a shot and it's pretty cool, the animations are good... There's a nice color combination but they don't say why they chose that color or if it worked. (P9)

In summary, visual examples such as screenshots of user interfaces based on a theory may provide a more actionable starting point for brainstorming than the theory itself. As brainstorming is more about generating many possible concepts than about creating the "right" solution, it may be possible to use related visuals to spur the interest of practitioners in exploring a given translational resource. These could include semantically related images, paintings, and memes. Examples do not need to be only images. Videos of User Interfaces in action, human behavior, and art installations might also be useful examples. Multimedia examples might be particularly applicable for Interaction Design, Service Design, Voice User Interfaces.

**Building.** Practitioners often reuse existing design patterns to speed up their work. Patterns can be found in online libraries of organizations that develop, document, and distribute their design patterns. Participants mentioned Apple’s iOS guidelines (P1, P15) and Google’s Material Design (P17) as offering helpful patterns. Practitioners also search for patterns in existing apps to learn how others have designed interaction, user experience, and visual aspects of experiences and how competitors have tackled a specific design challenge. Practitioners regularly send apps to coworkers:

we looked at that and we talked about how that could inform the way we would handle our filtering. There were some interesting ways we could draw from the way they did that.  
(P16)

Reviewing apps in this stage is used to “reverse engineer” others’ work (P13, P17).

When I analyze features of competitors, there’s an inherent idea that the design is working because it’s based on research, for example this project included improvements to the video-audio player. Guess what: there’s ten companies out there that have made audio players, and I’m sure Google has done a lot of research, so I went and looked at what Google had done, because I think I should just steal their patterns. In some sense, that is a proxy for their research. (P17).

Finally, forum functionality allows designers to ask and answer questions as well as to learn from existing questions and discussions around them (P1, P2, P8, P17, M20). After trying to build a complex gesture interaction, P2 said, “We would never had figured that out had it not been for other people asking in forums like StackOverflow” (P2).

**Advocating.** After tapping into knowledge from different resources, designers produce design directions to share with their teams or clients. However, proving that an idea is valuable is often hard, and ‘data’ can be used to win an argument: “In contentious debates you need to bring some sort of science or numbers behind it to prove a point” (P6). The main resources used for advocacy come from user research, resources published by trusted organizations, and, more rarely, academic research. Participants mainly relied on their own qualitative and quantitative user research data for advocacy, since it is more specific to their problems and audiences (P2, P6, P11, M21, M22).

‘Data’ can be a single summary of important behavioral insights or information visualizations. Quotes add nuance to statistics and humanize product discussions by making stakeholders more aware of user problems and needs. Designers said, “Quotes add a human element, and it puts you in that place of that research” (P17). Designers also present data, leveraging simple visualization techniques (P1, P6, P16, M21, M22): “In our research findings deck we used Google Forms’ pie charts and bar graphs to prove our points with hard data” (P1). Practitioners trust well-known organizations such as the Nielsen Norman Group, IDEO, Google, Apple, Facebook (P8, 10, P14, P17, M21), and sometimes, papers published at CHI (P9). Participants may also look for evidence in these resources: “Articles that present quotes, data, etc. adds to the authority” (P17).

## Discussion

This study confirms and extends previous findings on barriers to translating academic research to design practice. In this segment, I elaborate on previously identified barriers for Translational Research related to the content of academic publications. I also suggest ways to design practitioner-centered translational resources to support specific, important, design activities. Doing so may put more burden on academics to produce novel translational resources. I am aware of this limitation and recommend partnering with designers to produce translational resources.

Mainly, translational resources should contain examples tailored for specific design activities. They should also be made more actionable for practitioners.

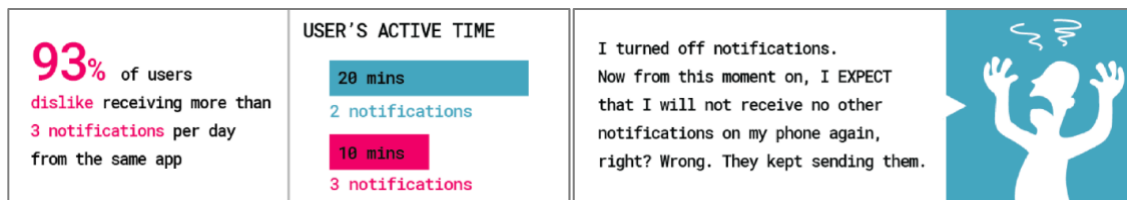
First, supporting prior work (Remy et al. 2015), I identified the need to aid designers in different design activities. This study uncovered four design activities where translational resources can help practitioners: understanding, brainstorming, building, and advocating. Consistent with Gray et al. (2014), designers prefer resources that are easy to visualize, use, and explain to stakeholders. Practitioners described using examples to support different design activities:

- **Understanding.** Practitioners use models to explain abstract concepts to others, facilitate team discussions, and visualize and sketch intervention opportunities. While it may be difficult to present the nuances of theoretical contributions and some other results visually, academics could still create visual representations of theories that show complex information in a more digestible manner. For example, ethnographic research contributions for the HCI community may not have clear design guidelines as an outcome (Dourish 2006). That does not mean, however, that there are not opportunities for ethnographers to develop visual representations of their results. Dourish suggested communicating moments and models which can be visually represented. Other artifacts created by ethnographers to provide a glimpse of research sites such as architectural details, blueprints, or navigation activity, might be another interesting way to model complex research outcomes in a more legible manner to practitioners.
- **Brainstorming.** In brainstorming, designers produce several potential solutions for a problem. This is an activity where practitioners benefit from visual examples to feed their creativity. I suggest partnering with designers to create these resources. Screenshots of user interfaces based on a theory may provide a more actionable starting point for brainstorming than the theory itself. As brainstorming is more about generating many possible concepts than about creating the “right” solution, in the absence of a product to use as an example, it may be possible to use related visuals to spur the interest of practitioners in reading more about a given translational resource. These could include semantically related images, paintings, memes, or pictures of design objects. Examples of similar or related applications do not need to be only screenshots of interfaces or related images. Videos of Uis in action, human behavior, and art installations might be useful examples if purposefully coupled with a translational resource. Multimedia examples might be particularly applicable for UI and interaction design, for service design, natural Uis, voice Uis, or audio pieces may be more helpful.

- **Building.** Design knowledge is embodied in design products. Allowing designers to experience design patterns through interactive features is more useful than only seeing or reading examples of how a design could work. To allow interactive exploration of examples, resource libraries could show prototypes or pieces of designs. For many platforms, exporting and distributing interactive prototypes is an open challenge, but there is emerging functionality allowing portions of native applications or prototypes to be loaded on demand, such as Android Instant Apps (n.d.) or Design tools (Figma, Adobe Experience Design, and others) to support exploration of interactive demos.

- **Advocating.** Designers often use data to advocate for a solution and to generate buy-in from decision-makers. Pursuing a new idea can take resources away from other projects, and so managers often require plenty of justification (Brown 2009). Translational resources can help practitioners to explain the strengths of design ideas by providing evidence with digested hard data and/or user quotes.

In Figure 18 I present two ways to present digested quantitative data. On the left is descriptive statistics. Participants referred to statistics as a single data point summarizing usage metrics insights or simple information visualization (Figure 18, left). On the right, qualitative information is presented using a real user quote, expanded by a drawing or photo of a frustrated user. Participants mentioned that quotes add nuance to statistics and humanize product discussions by making stakeholders more aware of user problems and needs (Figure 18, right). In internal resources, designers often integrate quotes into personas and illustrate them with pictures of users. Another alternative could be producing video vignettes to show real situations or convey participants’ feelings and thoughts more outwardly.



**Figure 18. Data representations to illustrate findings.**

Now, I will highlight two general aspects that seem important for the design of translational resources. These aspects are related to informational needs of the design practitioner audience, their keen interest in resources with visual qualities that they consider actionable, as well as resources that enable informal conversations with peers or like-minded professionals.

First, an important aspect of the examples that designers use to inform their work is their visual quality. Design practitioners are familiar with and enjoy the process of visually navigating and reviewing abundant examples of designs. Observing examples side by side facilitates quick scanning and comparison. Gallery-based websites such as Dribbble are a good example of how tools can be designed to support visual discovery.

Would you rather go into a room filled with color, pictures, and examples or a room with 100 pieces of paper with text on the walls? Which one would be easier and pleasant to find what you are looking for? (P3)

Second, I found an extremely pragmatic interest in information resources that are actionable and increase design productivity. Below, I describe how theory-driven resources could be designed for practitioners to find them “actionable.”

- **Actionable guidelines.** Researchers could write more actionable design guidelines in terms used by designers. Even when designers have access to digital libraries, they may not know the right search terms to use to find relevant resources. Vocabulary differences between researchers and design practitioners are significant barriers and may result from researchers focusing more on connecting design implications to theory and prior literature than on connecting to design practice (Carroll and Rosson 1992; Dourish 2006). Academics have acknowledged the need to reframe academic resources to communicate with designers (Fogg 2009; Hall 2013; Newell and Card 1985; Norman 2010) and to consider how their framing affects adoption by both academics and practitioners. Furthermore, as the HCI community encompasses practitioners, I suggest leveraging their perspective when coining new terms or borrowing terms from other disciplines. This practice might avoid tensions such as practitioner objections to the foreign or complicated terminology in academic research. Additionally, academics could partner with designers to create design guidelines or blog posts about their research. Participant M20 rewrote a design implication found in academic research to make it “actionable”:
  - Design Implication: “We propose skewing visualizations to present favorable comparisons. Designers can make user performance appear closer to their comparisons” (Colusso et al. 2015).
  - Design implication rewritten by M20: “To motivate gamers to play more, *upscale* [sic] their performance so it looks closer to what they’re being compared to.”
- **Design challenge framing.** It also seems like a design challenge framing could help designers identify and understand relevant resources. Academic researchers often start a study motivated to test a theory and discuss their research in terms of that theory. As a result, designers think findings in the resulting papers are distant from the “real problems” they face (Norman 2010). Consider the design challenge of how to facilitate navigation with cues about users’ location in a site. One of the possible solutions is the breadcrumbs design, which offers clickable links of the hierarchical path that leads to the current page. Designers can run a web search to find breadcrumbs designs, finding few academic results. Moreover, academics might have studied other navigation strategies, but since the keywords are not semantically related to breadcrumbs, designers may never discover these resources.
- **Easy to use design resources.** Creating new resources, such as “plug-and-play” design patterns, UI templates, stencils, and icon kits, could better integrate theory-driven resources into practitioner workflows. Design patterns are valued by practitioners for helping them work more efficiently. Design patterns containing interaction and style collections (Google’s Material Design, Apple UI guidelines) provide tangible parts that designers can use. It is common for design patterns to be accompanied by snippets of code that can be used with little modification, speeding up the design process (Sharp et al. 2015). Some academics already do this (e.g., information visualization with interactive prototypes and galleries of examples) but these activities often conflict with incentives for academic researchers, since

these contributions usually do not receive credit. However, creating design pattern libraries could enhance the impact of academic research labs, helping to find industry collaborators and new students. Academics could partner with designers to build these resources.

Finally, I noticed that designers promote a sense of team inclusion by constantly sharing ideas, sketches, and prototypes with their peers. These communication artifacts are shared in team meetings to explain concepts, incentivize feedback, and start conversations with stakeholders. I acknowledge the difficulty of promoting conversations between practitioners and academics, and the study presented in this chapter does not solve this issue. However, it is clear that the development of translational tools and resources should strive to integrate into or improve upon existing practices.

Such conversations could be supported through tools that both designers and researchers use or by integrating distinct tools. Designers could directly prompt coworkers and academics by showing incomplete designs and asking questions via Slack, Microsoft Teams, or plugins for Adobe tools, Sketch, etc. These could connect with tools commonly used by academics such as research discussion groups, Google Scholar, or Academia.edu. In addition, academics could be more proactive and initiate conversations with designers. For example, AMA (“Ask Me Anything”) sessions on Reddit or Slack groups tend to be successful in starting conversations. Academics would benefit from learning more about issues with which designers struggle and how they are applying concepts in practice. Designers’ successes and failures may identify new ways to instantiate theories in designs and gaps in theories. Their experiences may also challenge theories. It is possible that these conversations could also lead to collaborations between researchers and practitioners. Also, professional societies such as User Experience Professionals Association (UXPA) and Special Interest Group on Computer-Human Interaction (SIGCHI, one of the Association for Computing Machinery’s special interest groups focused on HCI) work to connect academia and industry through events, workshops, and mailing lists. Building on their work and membership may be a good starting point for future Translational Work. Such findings support a two-way communication model, which seems more appropriate for bridging research-practice gaps such as  $T_{BD}$  and  $T_{AD}$ , than a one-way model.

## **Summary of Contributions**

Two main contributions arise from this study. First, I characterize the barriers that design practitioners face in using resources produced by academic research, and how designers use information resources in their practice. Second, I propose translational resource formats to support specific design activities, fitting into HCI practitioners’ informational needs and contexts. Using these proposed formats, research-producers and communicators are more likely to create theory-driven resources that inform the work of design practitioners.

In the next two chapters, I develop and evaluate tools to test the feasibility, usefulness, and consequences of recommendations. The next two chapters outline design-oriented studies that tackle two specific translational barriers in HCI: understanding (Chapter 5) and applicability (Chapter 6).

## Improving Understanding

In this chapter, I tackle the translational barrier of understanding, which is especially influential in the gap between basic research and design practice ( $T_{BD}$  in the HCI Translational Science Model, Figure 19). I focused my intervention study on the opportunities for design students to build the skills to effectively read and understand scientific research. Specifically, I asked: “How to facilitate nonacademics’ reading and understanding of scientific research?”

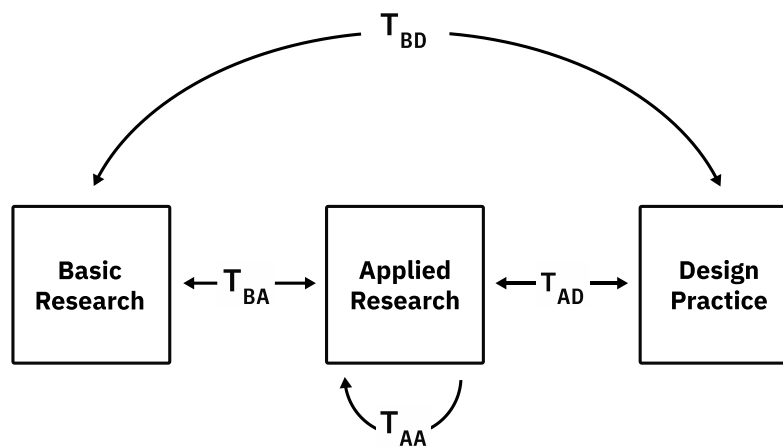


Figure 19. The Translational Science Model for HCI.

Responding to a common perspective that design practitioners do not read or do not understand research, I work to counter this barrier by enhancing HCI/UX practitioners’ abilities to understand existing scientific publications for use in design practice. One could think of many ways to bridge this gap. For example, researchers themselves or third parties could take on the work of translating scientific publications for practitioner use. However, the gaps between research and practice are not unidirectional as seen in Chapter 3 and 4; many practitioners are interested in reading science.

This work situates primarily in the context of a classroom. I do not claim that classrooms are the only channel for HCI/UX practitioners to read and translate scientific research or that design students are fully representative of the practices of practitioners. However, the classroom is an important “translational site”

where, in our case, academic researchers and soon-to-be design professionals meet to construct knowledge and tangible design work. The Translational Science Model for HCI presented in Chapter 3 shows how Translational Work may happen through teaching, especially considering that students go on to shape HCI practice.

Such an approach also highlights that knowledge users must be able to understand how knowledge that is being communicated can be applied to problem-solving. This concept of engagement can not only make translations more relevant and effective, but also build the perception that associated groups are truly concerned, will listen, and will be able to provide useful information. These relationships can become channels for successful knowledge sharing over time (Chapter 3).

In this particular study, I observed and interviewed two cohorts of students enrolled in a graduate-level course in two consecutive years. The course instructors, in this case my graduate advisor and I, tasked students to read and translate scientific publications into design resources, activities which we scaffolded and evaluated.

This chapter outlines two practical contributions of this work: 1) the design of a learning module consisting of two novel exercises to support designers in reading and translating scientific publications, and 2) opportunities for educators seeking to improve HCI/UX students' ability to read and use theories.

## **Related Work**

As seen in the preceding chapters, the research-practice gap in HCI is a narrative exposing the barriers preventing a healthy relationship between researchers and design practitioners. Many barriers are at play, and they can be allocated into specific gaps, as I propose in Chapter 3.

One of the main translational barriers that has prevented the adoption of academic work by practitioners is one of understanding. To address this problem, HCI scholars have advocated the translation of scientific findings for practitioner consumption (Norman 2010), which is in fact the dominant approach that HCI academics have chosen to bridge theory and practice (Gray et al. 2014; Roedl and Stolterman 2013; Stolterman 2008). However, the sheer amount of published scientific research, along with its defining context—how research findings are framed in specific technological and societal boundaries (Dourish 2017)—makes it difficult and costly to translate all existing scientific research into resources that designers could directly use in their practice. The general perception that theory is difficult to read is often attributed to the scientific writing style, with its dense argumentation patterns and highly intricate descriptions and definitions (Toulmin 1983). Past work found this perception to be consistent among design practitioners, as seen in Chapter 4: “When I think of research, I think I’m going to have to slowly go through tons of reading with big vocabulary words, because someone wanted to sound smart in their thesis” (P3, Colusso et al. 2017).

Following the trajectory of my dissertation, I propose an alternative approach: using a scientific literacy lens may suggest equipping HCI/UX students and professionals with the tools necessary to independently read, understand, and use science (ACRL 2000; Jonhston and Webber 2003; Norris and Phillips 2003). For Bybee (1995) and Hand et al. (2001), the most relevant scientific literacy skills

include understanding science and how it relates to problems and issues involving technology, society, and the environment, and the skills necessary to inform and persuade others to take action based on these ideas. In other words, scientific literacy can be developed with the skills required to construct understandings of science and how to use scientific findings for problem-solving.

Researchers have designed and investigated reading and writing exercises to increase scientific literacy. In general, directives to read “critically,” although benign in intent, are useless without tangible instructions for the reader (Shon 2015; Yore et al. 2003). In contrast, researchers defined goal-oriented, scaffolded, and focused exercises as active reading techniques (Shon 2015; Tashman and Edwards 2011; Yore et al. 2003). Such active reading techniques include annotating texts, extracting and organizing content, self-explaining, and design-oriented techniques such as envisioning use and translating theories. Annotation involves building upon specific parts of the original text (commenting, underlining, circling) while reading to increase understanding and recall (Morris et al. 2007). Shon (2015) cautions that each part of a scientific text serves a specific function, which students need to understand before “abusing” notetaking. Extraction involves copying original content to a notebook (Hinckley 2012), which over time becomes a catalog of learnings. Reading notebooks is quicker than reading entire publications again and may facilitate recall as notes are organized following readers’ viewpoints (Adler et al. 1998; Osborne and Wittrock 1983; Schilit et al. 1998). Self-explanation can increase one’s ability to convey complex ideas (Adler et al. 1998; McNamara et al. 2004; Osborne and Wittrock 1983), a high-demand skill for HCI/UX professionals (Kreitzberg et al. 2019). Education scholars recommend paraphrasing to raise awareness for understanding gaps and in turn transforming a source text into familiar, memorable ideas that can increase topical understanding (McNamara et al. 2004).

Finally, a promising approach to develop the scientific literacy of HCI/UX practitioners is by exploring the use of science for problem-solving, which involves translating theories into design resources. Norman (2010) argued for the need for “translational developers who can act as the intermediary, translating research findings into the language of practical development and business” (p. 12). Such language is diverse and, according to past work, is driven by the need to tackle specific and complex design activities (Chapter 4; Kreitzberg 2019). Prior work in Chemistry education highlights the value of creative educational materials such as card creation, which helps students learn, understand, and apply content-specific concepts (Mariscal et al. 2012). Within HCI education literature, scholars advocate for a practice of teaching and learning that balances methods and technology use with reflective and situated practice (Koutsabasis and Vosinakis 2012).

## **Design of the Learning Module**

Following the tracks of past work and the trajectory of my studies in Translational Research, I created a learning module as an intervention to help design students to read and understand theory in the context of an academic course that connects Behavioral science with digital design. The learning module comprised initially of a reading guide activity and a card creation activity. I took a skills-based approach (Wagner et al. 2002) to help students build their ability in reading theories, mainly using prompts for activities in which students engaged in active reading and translating theories into design cards. In the

following sections, I explain what the two activities in the learning module are, their specific goals, and how I developed them.

### *Reading Guide*

As found in prior work, designers often do not engage with theory in their practice because reading scientific works can be time consuming, and the value they get may be minimal, as scientific findings do not seem applicable to their context (Chapter 4). Therefore, the goal of the reading guide is to facilitate reading scientific publications and understanding the value of theories for design.

The activity was highly scaffolded with respect to how much time students spent on each task or the expected length of their responses (Shon 2015). I focused on two main areas of scientific literacy drawn from Bybee (1995): 1) developing the abilities of students to understand scientific knowledge and how it can be used—or misused—in problem-solving, and 2) providing students the tools to do so independently.

Specifically, to encourage learning and recall, I asked students to annotate publications, reflect on theories via summaries, and to rewrite their interpretation of theories in their own words. Students were also asked to identify aspects of the reading that connect with their lived experiences (Freire 1996). Whenever students produced a piece of content in reaction to the publication, there was an associated reflection task along with it.

After reading the publications, students informally discussed their active reading findings in class with peers and instructors. This discussion was not structured or designed in any specific way at the start.

**Table 9. Reading guide prompts.**

- |   |
|---|
| <ol style="list-style-type: none"><li>1. What in the reading was the most surprising concept/construct? Something that you could use in your design practice or that inspired you to search for additional information about the theory? Something that addressed a real behavioral problem present in society?</li><li>2. Give a catchy title to a design strategy extracted from this paper. Action verbs are good. Use 70 characters or less. 1 minute.</li><li>3. Briefly explain the strategy. 280 characters or less. 3 minutes.</li><li>4. Explain 2 or 3 real behavioral problems faced by people that this strategy can solve. Use 140 characters or less for each. 5 minutes.</li><li>5. What is the specific theoretical concept/construct that is connected to the recommendation above? Copying and pasting from the paper is okay. Use 70 characters or less. 1 minute.</li><li>6. Search for an image that showcases a design example that can be connected to the theoretical concept/construct drawn from the paper. 10 minutes or less for your search. If you can't find any proper image, write below what kind of design could explain this concept to others. Describe the image and how it is connected to the theoretical concept drawn from the paper. 3 minutes and 140 characters.</li><li>7. Find an image to conceptually represent the design strategy. Use keywords related to the examples of 2 or 3 real behavioral problems outlined previously. It can't be an interface screenshot. 10 minutes.</li></ol> |
|---|

If you can't find an image, describe the optimal image to explain this concept to other designers. In 2 minutes and 140 characters, describe the image and how it is connected to the design strategy.

8. Why would this strategy work to encourage behavioral change? Provide a convincing argument using existing evidence. If you use data from the paper, explain what this piece of data means in practice. Evidence can be quotes from research participants drawn from the paper you read. Evidence can be statistics drawn from the paper or direct quotes from the paper. 10 minutes and 280 characters or less.

9. What ethical concerns does the application of this theory to design raise? Reflect on the occasions in which this strategy should not be applied. Explain why it shouldn't be applied, in terms of potential negative consequences of using this theory to change people's behaviors. If it should be applied carefully, how and why? Use 280 characters and 10 minutes.

### *Card Creation*

An important part of scientific literacy is understanding how scientific findings can be used in problem-solving (Bybee 1995). However, practitioners struggle to envision how theory can bend into useful design strategies (Chapter 4). Therefore, the main purpose of this activity is to support students in translating theories and understanding how to use them for problem-solving. I hypothesize that the activity-based learning process could allow practitioners to discover theoretical principles and concepts themselves. Instead of being told how theory should be used, this process encourages appropriating theoretical concepts based on practitioners' own experiences (Gray et al. 2014).

Here, I asked students to generate a design card. I gave students a Powerpoint card template with prompts to facilitate translating a theory into design strategies. Students were first asked to identify a particular aspect of the theory that they were interested in exploring in-depth to reduce the scope of the theory, making it more manageable. Next, the prompts asked students to name, define, and visually represent what they learned about the theory, as well as to envision design strategies based on the theory. Students were then asked to explain and describe the strategy at a theoretical and practical level and identify strengths and ethical limitations of the envisioned strategy.

**Table 10. Card creation prompts.**

1. What was the most surprising concept/construct? What was something that you could use to design? What addressed a real behavioral problem present in society?
2. Create and briefly explain a design strategy drawn from the theory. Write 2 sentences.
3. Find images to represent the strategy at conceptual and practical levels. 1 image has to be of a design. Search for fun or eye-catching images. Describe the images and how they are connected to strategy drawn from the paper. Write 2 short paragraphs.
4. Describe Dos and Don'ts to guide usage of the strategy. What is the recommendation for designers? What should designers avoid when using this strategy?
6. Why would this strategy work to encourage behavioral change? If you are referencing a paper that contains empirical research, use data (statistics or quotes) from the paper and explain what it means in

practice. If the paper does not have data, provide a convincing and logical argument for the use of your strategy.

7. Review all of the content in the card to reflect ethical reasoning. What ethical concerns does the application of this theory to design raise? Reflect on the occasions in which this strategy should not be applied. Explain why it shouldn't be applied, in terms of potential negative consequences of using this theory to change people's behaviors. If it should be used carefully, how and why?

Below, see images of the two activities comprising my learning module. Find the full exercises in the Appendix.

The figure displays six screenshots of an active reading guide, arranged in a 2x3 grid. Each screenshot contains a different exercise or prompt for students to complete. The exercises include:

- Exercise 1:** Choosing one of four prompts to focus on a particular aspect of the theory for the next parts of this reading exercise. The prompts are:
  - Was the most surprising concept/construct?
  - Was something that you could use in your design practice?
  - Inspired you to search for additional information about the theory?
  - Addressed a real behavioral problem present in society?
- Exercise 2:** Briefly explain the strategy (200 characters or less, 3 minutes to write it down).
- Exercise 3:** Explain 2 or 3 real behavioral problems faced by people that this strategy can solve (140 characters or less for each, 5 minutes to write down the problems).
- Exercise 4:** What is the specific theoretical concept/construct from theory that is connected to the recommendation above? (Copying and pasting from the paper is ok, 70 characters or less, 1 minute to write down the concept/construct).
- Exercise 5:** Search for an image that showcases a design example that can be connected to the theoretical concept/construct drawn from the paper. (10 minutes for your search or less, if you can't find any proper image, write below what kind of design could explain this concept to others).
- Exercise 6:** Describe the image above and how it is connected to the theoretical concept/construct drawn from the paper. (3 minutes for your search or less, 140 characters or less).
- Exercise 7:** Get an image that presents the underlying insight at a conceptual level that can be connected to the theoretical concept/construct that you approached on the questions above. (You can use keywords related to the examples of 2 or 3 real behavioral problems outlined previously).
- Exercise 8:** Describe the image above and how it is connected to the theoretical concept/construct drawn from the paper. (2 minutes for your search or less, 140 characters or less).
- Exercise 9:** Why would this strategy work to encourage behavior change? Provide a convincing argument using existing evidence. If you use data from the paper, explain what this piece of data means in practice. Evidence can be quotes from research participants drawn from the paper you read, Evidence can be statistics drawn from the paper/paper you read, Or direct quotes from the paper (quoting experts). (200 characters or less, 10 minutes or less to gather evidence).
- Exercise 10:** What ethical concerns does the application of this theory to design raise? Reason about the occasions in which this strategy should not be applied. Explain why it shouldn't be applied, in terms of potential negative consequences of using this theory to change people's behaviors. If it should be applied carefully, how and why? (200 characters or less, 10 minutes or less).

Figure 20. Active reading guide.



The two activities represented above were designed to be used and evaluated in 2018. Read more about the evaluation methods in the next section.

## **Methods**

I explored reading and design engagements between graduate students and scientific publications over two separate courses offered consecutively in 2018 and 2019 and in two separate evaluations. The context of this study were two traditional academic course (one session per week, four hours per session, 16 students each, 32 students in total) offered in an interdisciplinary HCI masters program. Students from both cohorts came from diverse intellectual cultures and from academic and professional backgrounds. Overall experience levels with design and engineering were intermediate, while academic research expertise was minimal. Most students had professional experience working in technology companies as designers or engineers. Finally, the courses were not required in the academic program where it was offered (Human Centered Design and Engineering, the University of Washington), suggesting that students may already have been interested in behavioral sciences.

My results report students' perceptions and instructor observations of the use of the learning module. Students answered two anonymized surveys, one at the start of the course and another after the course ended. I asked for students' perception of their proficiency in reading and understanding Behavioral science. See the full list of readings used in the course in the Appendix. After submitting grades, I interviewed 19 students (referred to as "P#") to understand their experiences in detail. I conducted, audio recorded, and transcribed interviews (ten interviews and nine hours of audio in 2018, nine interviews, ten hours of audio in 2019).

I worked with a research assistant to code the interview and survey data and then to identify and discuss preliminary themes. We used a traditional framework analysis with a code frame reflecting the same set of themes that guided the design of the activities. The research assistant and I convened once a week to discuss how the initial set of themes, as well as emergent themes, supported (or did not support) students in reading, understanding, and translating theories. We discussed themes until we reached a consensus. The same codebook used in the first evaluation in 2018 was used in the second evaluation in 2019. We synthesized our themes according to needs, challenges, and the functional definitions of each activity. Each theme was elaborated into paragraphs and quotes that represented both the general view of participants as well as dissenting perspectives.

Finally, in a member-checking phase (Lincoln and Guba 1985), I interviewed five design instructors (referred as "DI#") who taught social science theories to design and HCI students. Instructors challenged and elaborated on findings, which served to improve accuracy and depth.

## **Results of the First Evaluation**

Here I report results following the scientific literacy definition of understanding theory and how theory can be used (Bybee 1995; Hand et al. 2001).

## *Reading Guide*

In this section, I first describe the drawbacks in my initial approach to active reading which led to a fruitful observation of organic practices that can lead to science comprehension. I also found that peer discussions were very important to support understanding theories and that these peer discussions needed more scaffolding.

First, the active reading guide, although engaging and useful, had too high a cost of production. Students appreciated how the specific prompts of the guide helped them to understand dense readings, leading to the discovery of key concepts (P3, P5, P10, P14, P15). “I thought it actually was helpful because you have an activity on the side, you’re searching for nuggets, you’re searching for something important. So, it keeps you more engaged” (P15). Although they mentioned that the guide helped them to understand theories in detail, it was also too cumbersome. Most students complained about the amount of time and effort required to respond to the active reading prompts that I had created. Students informally mentioned that the guide led them to “writing a research paper every weekend.” Participant 15, who earlier had mentioned how engaging the activity was (see previous paragraph), summarized the experience of using the activity to read a scientific publication: “Sometimes it takes like, three hours to get through each research paper. I used to get nervous about how long it would take, like look up all the words and everything” (P15). After getting many requests from students, I decided to pause using the guide to keep all students motivated to at least read the assigned readings in the remainder of the course.

Without the reading guide, students were expected to come to class prepared for a discussion after reading the assigned readings, which is the general approach used in most classes. This allowed me to observe organic practices that could be used for a redesign of the guide. Students unsurprisingly followed a somewhat disorganized approach without clear goals (P4, P5, P11), such as highlighting and noting points that they thought were important at the moment of reading (P4, P5, P10, P11, P14), concepts that they thought could be “useful” or “concrete advice” for the course or in the future or that they found “actionable” (P4, P5, P10, P11, P14). Interestingly, students did catalog notes for further reference in indexed digital documents or binders (P3, P5, P10, P11), which I had tried to encourage earlier with the reading guide. I also noticed that students gradually started to identify differences between different types of publications as well as different functions of parts of publications. Different kinds of papers, or different parts of publications, may focus more on explaining concepts and summarizing findings or explaining applications of concepts (i.e., theory summaries and empirical studies). Students found that theory summaries, although helpful to understand theories in depth, can be too broad, abstract, and present too much diverging nuance (P7, P10, P15). Although students found that empirical studies were more helpful to extract design recommendations and examples of how theory can be instantiated, the studies made it more difficult to understand theoretical concepts, as these were further removed from the broader theoretical context (P1, P4, P5, P9). Such findings point to the issues of navigating the specificity of scientific contributions and how they can be translated by attempting to make them more or less specific.

Second, although not a formal part of the activities that I designed, most students found that discussing learnings with peers was one of the most important pieces to understand theories. Students’ general perception was that “when you have to explain something to someone, that means you actually get it” (P15). Discussing the theories with peers exposed students to alternative perspectives, which could have increased comprehension of the theories. “It was helpful to hear from peers how they thought about certain theories. I often found myself saying ‘Oh I didn’t think about it that way, but I totally see that,’ which I think is helpful” (P5). The benefit of peer discussion comes with its own challenges, especially when students do not read the assigned text, which could result in less engaging exchanges. Finally, interestingly, students underscored the value of practicing discussion and rhetoric skills to advance in their professional careers, mentioning that using talking points from the publications helped to practice such skills.

### Card Creation

In this section, I outline successes and challenges of the card creation exercise in helping students explore the applicability of theories. Overall, I found that students enjoyed the exercise of creating design cards because it led to interesting design-oriented explorations of theories. Students said the cards allowed them to focus on specific aspects of theories and to create applied recommendations based on theories while productively engaging with peers. See examples of cards in Figure 22.

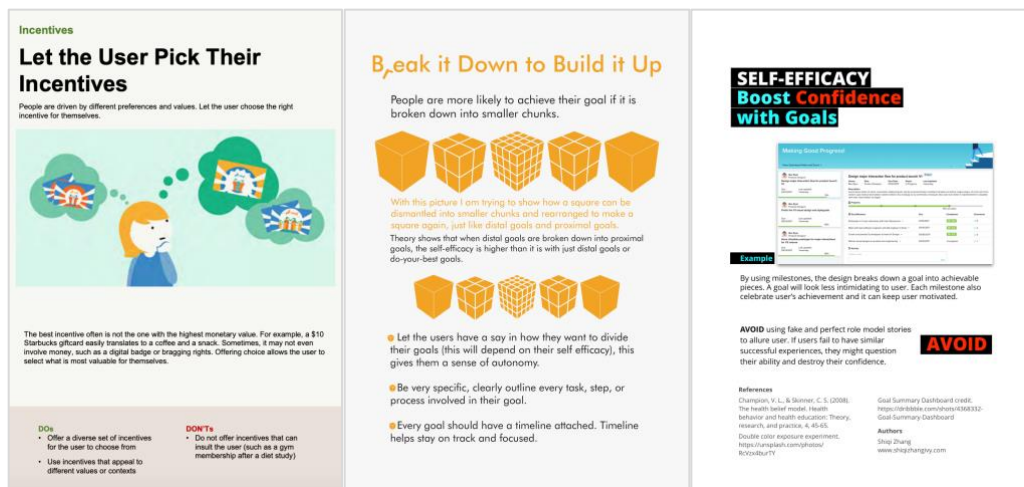


Figure 22. Three examples of cards created by students.

First, most students thought that the card creation exercise represented a “forcing function” that encouraged them to “pick out one or two small parts of what could otherwise be a complex reading, and then expand on those elements in a design card” (P13).

Second, P14 and P15 further stated that the constraints of creating a card led to creative ideas of design strategies based on theories. Interestingly, some students were stimulated to envision novel research and moderation strategies based on theories. Two creative examples were a step-by-step guide for co-designing workshops and recommendations for recruiting diverse populations for user research.

Third, I found that the card exercise augmented the value of peer discussions such that students could envision and hear a broad spectrum of scenarios for the use of theory. Most students said that discussing theories with peers gave them an alternative perspective not only on the meaning of theories, but also on their potential application for problem-solving. Peers often raised questions or offered input based on their professional experiences, and students came from diverse backgrounds—for example, Engineering, Visual Communication, Social Sciences, Finance. Such exchanges allowed students to place themselves in the shoes of an expert audience and evaluate the “usability” of theory (P10, P15).

There are also opportunities to improve the card creation exercise. I heard from students that the most thought-provoking parts of the exercise were also particularly challenging.

First, students mentioned that translating the differing specificities of theories into design strategies enriched their learning experience. Although it was challenging for them to zoom out of a scientific finding when it was very specific or to zoom in when a theory was very generally presented, the precision and nuance of theories made it difficult to synthesize specific design strategies for the cards (P3, P5, P8, P10, P13, P14, P15). Inversely, when publications had general discussions of theoretical concepts, students had to take these concepts and situate them in specific design strategies. For P14, “it [was] difficult to boil [general theories] down into a very direct, actionable idea.”

Second, students found searching for visual or design examples to be insightful, as it encouraged careful thought about the applicability of theories. Still, students hit a wall in finding examples that illustrated theories. Students first looked for visual examples in the publications (e.g., diagrams), and then elsewhere. Six students spent hours trying to find images on Google Images. Two students designed their own examples. Two students used Google Scholar to search related articles in the hope of finding visual aids. Interestingly, P11 wanted to share a screenshot of a notification that a weight-loss mobile application provided them a few months before the course. However, that same use context could not be reproduced, and the student could not find the design to use in the exercises.

### *Summary of Findings that Guided an Iteration of the Learning Module*

To drive improvements in the learning module, I organized and articulated the three main findings from the first evaluation. Below, I explain the main problems faced by students in the first evaluation and the insights that informed an iteration of the module. Refer to Appendix for the full exercises. In summary:

**Finding 1:** Active reading seemed useful, but the extensive reading guide did not offset the burden of reading dense scientific publications, which led me to drop the guide in the previous evaluation. The most notable change in the second evaluation was the reimplementation of the reading guide. With a redesigned reading guide, I wanted to provide more specific guidance on how to find content in the publications and elsewhere on websites and related publications. Specific changes I reimplemented the reading guide with included:

- **Specific guidance on how to read publications and the amount of time needed.** In the first iteration, I did not highlight the functions of different parts of a scientific publication or the differences between the types of publications that I assigned for reading. I gave specific guidance for students (e.g., recommendations and sensemaking of findings might be in the discussion section, definitions in the introduction or related work) and also provided suggested time limits for activities based on average times that students mentioned: 90 minutes of reflection and notetaking after reading the publication.
- **How to search for theoretical definitions.** Previously, I told students that they could use Google scholar, but I noticed that simply looking for definitions in a dictionary or Wikipedia can facilitate exploring concepts. I kept the directions to paraphrase and reflect on any information extracted from publications or elsewhere.
- **How to search for figures and images that explain theory.** I noticed the importance of diagrams that explained the theories in publications. However, not all publications have these. I guided students to look for theory representations on Google Images and also in other publications about the same topic on Google Scholar.

**Finding 2:** Although the card creation exercise worked well in general, translating theories into design strategies was inherently difficult. I noticed two areas with opportunities for improvement. First, a single publication often presents theories in varying degrees of specificity, a variation that is even more pronounced when comparing different publications. Students seeking to envision applications for theories noticed that theories or findings may be at different levels of specificity but may still end up confused. Second, I noticed a more practical problem of finding visual representations for theories, which, although challenging, seemed important for exploring and understanding theories. Specific changes I made in the card creation activity included:

- **I added more prompts related to theory specificity and applicability.** I encouraged students to envision design strategies and other creative theory-driven strategies as they saw fit. I noticed that students had creative ideas based on theories for novel user research methods and strategies or even ideation sessions. An example of a prompt to envision the applicability of theoretical concepts was to explore ideas of user research techniques beyond exclusively focusing on design.
- **Previously, I did not give explicit guidance on how to search for images.** To deal with how lengthy the search process of visual representations was, I created very specific guidance to find and make two types of examples for the card based on organic search practices and findings from the previous evaluation. I asked students to find or produce one image to represent the theory at a conceptual level, without worrying about application. Such examples could be found in free stock photo websites (I asked students to write the appropriate credits for images). I also asked students to find or produce one design example to illustrate the potential applicability of a theory. After observing how students did that organically in the previous evaluation, I listed a few resources that could help, such as Dribbble, Pinterest, and other UI libraries sites, as well as explicitly mentioning that they could create their own designs.

**Finding 3:** I found that explaining theories to peers was seen by students as a valuable activity on top of the reading guide and card creation. Discussions and briefing exercises seemed promising for further understanding theories, envisioning their applicability, and also practicing presentation skills. Specific changes I made to the learning module included:

- **I formalized and scaffolded peer briefs for students to practice such skills in a manageable situation.** I asked pairs to explain theories to each other to practice explaining before the always-intimidating experience of espousing one's perspective to the entire classroom—as in pair discussions first and open-class discussions second.
- **I noticed how students benefited from their peers' diverse expertise to improve or to envision different theory-driven strategies.** Students' different backgrounds facilitated a fun, interesting sharing process. Therefore, in the new learning module, I particularly encouraged sharing diverse ideas and discussing theories by situating ideas of strategies within real designs or professional scenarios. Such strategies were meant to leverage peers' expertise to raise potential theoretical uses or drawbacks of theoretical use, exposing students to different ways of looking at a theory and its potential use. Finally, I also explicitly prompted students to observe and discuss the nuances of theoretical terminologies as well as how broad or specific theories were.

## Results of the Second Evaluation

I used the same procedures as in the first evaluation, and the characteristics of participants were nearly identical. In this section, I primarily focus on reporting the results of iterations to address the three main findings from the first evaluation.

### *Reading Guide*

In the second evaluation, students thought that the reading exercises had a positive impact on their ability to read and understand publications (P1, P3, P4, P5, P6, P8, P9, P10, P11). This time, I did not drop or make changes to the exercises during the course.

Again, students enjoyed a practical, structured approach to navigate dense, long publications (P1, P2, P5, P6, P9). DI1 supported the importance of this finding; their students did not use a formal reading guide, but on the first day of class, DI1 gave a live demo of how to skim a scientific publication.

Students mentioned that the guide created a “focused mindset” and that with clear objectives it was easier to engage with the text (P1, P4, P5). Differently from the first evaluation, the redesigned scaffolding and specific guidance of how to find and engage with the content seemed to offset the cost (time, effort) of exercises:

Because I had become so familiar with the guide, that's how I started reading the theories, because I have to answer these questions. So I think that really made me read very intentionally, which was good. And by week four or five, I started realizing the value of the guide is just not a way to impose the reading, but more like, like, because the

papers are so huge sometimes you get just lost in them. And you might not know what you came out of, like what you got out of it. But the guide forced us to think about that, that makes you read better. (P8)

Responding to the changes that I made, students were able to look up definitions and find images more effectively. The redesigned reading guide offered specific recommendations that directed students to sections in the papers for understanding theoretical concepts. Two students specifically stated that they relied on the abstracts for writing theory summaries (P5, P6). Other students mentioned the discussion section of the reading guide because it helped them to extract ideas for design strategies from the theory (P3, P8). Students noted that the reading guide also helped them better understand various theoretical constructs and their relationships (P1, P5, P11). This was achieved by identifying theoretical constructs from the publication and looking up their definitions to construct a solid explanation about the theory. The suggestions for how to search for content also helped to alleviate some of the burden to look up images that conceptually illustrated or explained segments of the publication (P3, P4). More importantly, students understood the value not only of extracting content from publications or paraphrase segments, but also of reflecting on what theories mean—students specifically valued the task to reflect on what theoretical concepts mean for their practice (P3, P6, P8, P9, P10, P11).

Students went on to compare the course to other theory courses in the program, in which they read design and HCI publications. In comparing courses, students said they preferred using the active reading exercises compared to “regular reading” because it helped them to “read with intention” and grasp the content of the publications (P1, P3, P4, P5).

Despite the seeming success of the redesigned active reading guide, I found that it also introduced an unanticipated challenge. Students struggled to find validation for their active reading work. For example, since I did not provide explicit grading and feedback for the reading guide, students did not know if their notes were “right or wrong,” which was frustrating for them (P4, P6, P10).

### *Card Creation*

Once more, students thought that creating cards was difficult but ultimately helped to reveal how theories can be used for “real” problem-solving (P4, P5, P9, P11). For example, students felt that learning more about the “why” of human behavior from theory would help them better understand results from the user research they do at work. They mentioned, for example, that if they conducted interviews with participants, results could be compared to established theories to either support their findings or help to identify and explain variations in the findings.

Two lingering issues that challenged students were finding appropriate design examples to illustrate cards and how to deal with the tradeoffs between specificity and generality when translating theories into design strategies. First, overall, I observed that the design examples chosen for the cards made by this second cohort of students was more representative of theories than in the first year. Although most students felt that associating theories with design examples was very beneficial to understand theories and their potential applicability (P1, P3, P7), they still struggled with finding these examples, as currently

there is a lack of repositories focused on such topics (P4, P6, P8, P9). Guidance on searching for design examples on specific websites that I curated did help, but not to a point where students could put more effort towards making sense of theories and examples. Students pointed out the obvious—none of the sites that they used had search functionality that connected real designs to theoretical constructs.

Secondly, students mentioned facing “decision paralysis” (P9) when faced with a highly nuanced theory and the task to generate a single design strategy based on it (P1, P2, P3, P8 P9, P10, P11). However, I was surprised to hear that some students wanted to dive deeper into multiple aspects of a single theory, as they did not want to neglect important details (P1, P4, P12).

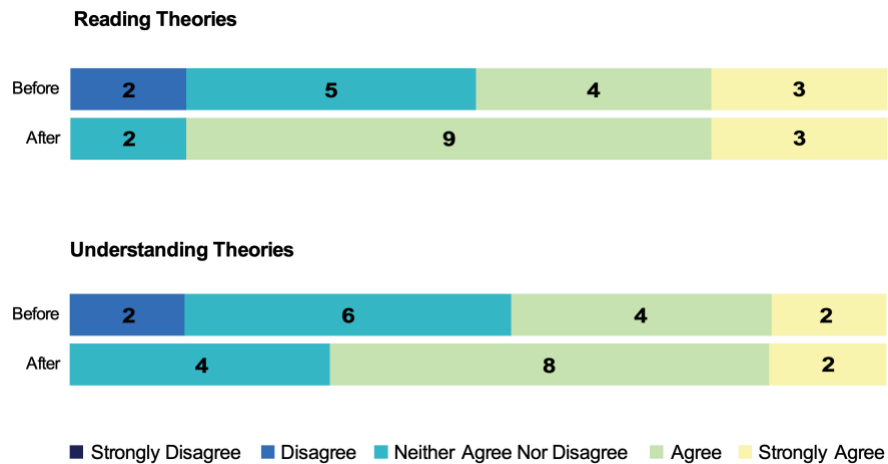
### *Peer Discussions*

Students again mentioned that peer discussions were important learning experiences and enjoyed the opportunity to practice presentation skills while using theory as part of their arguments. Students used a scaffolded discussion protocol to engage with the nuances of theories and constructs via examples and their diverse backgrounds.

First, productive discussions about theory were those grounded in design examples and engaging with theory specificity. From students’ perspective, whenever there were relevant design or user research examples available to be discussed in light of a theory, the exchange was more engaging and productive. Students also valued how their peers could add different perspectives to the discussions, as I attempted to pair students with diverse backgrounds. P1 even mentioned that this was a “bonus”—they learned about theories in the class and also more about user research from an experienced colleague. Other students complained about the difficulty of discussing the specificities of theories and how they may or may not be applied to different design contexts. I observed that, although difficult, very productive discussions emerged from this matter as instances of critical thinking in which students challenged theories and proposed adaptations based on their professional expertise. For design instructors in the member-checking phase, these findings were the most interesting, and they were excited to implement tactics for productive discussions between students.

Second, as in the previous evaluation, students highlighted that articulating their emerging knowledge to someone else who was also knowledgeable on the same topic was a key skill to develop as an HCI/UX practitioner. Again, students discussed how important this skill was for their professional careers and expressed that the terminology and theoretical concepts learned in the class could help. Based on my observation, and on students’ self-reported data, students seemed more confident in their knowledge on theories. In turn, although I further structured the peer discussion to make for easier and less intimidating discussions, I could not bypass the issue of students feeling frustrated when their peers came unprepared to class without having read the publications (P4, P5). This seemingly trivial classroom adversity became a larger issue, as peer discussions are powerful opportunities for students to correct any misunderstanding they have of a theory. Students also reported that the structured approach in the exercise provided them more confidence with reading scientific publications in general. Figure 23 shows data from the second

evaluation, where I noticed an upward trend in self-reported proficiency in reading and understanding theory.



**Figure 23. Data from the second evaluation.**

## Discussion

In this chapter, I presented an exploration of two exercises to facilitate the understanding of theories, a key translational barrier identified in this dissertation. Through a scientific literacy lens (ACRL 2000; Johnston and Webber 2003; Norris and Phillips 2003), I strived to equip students with the tools necessary to read, understand, and use science.

The first exercise was a reading guide that provided students a set of tasks to perform as they read the papers. The second was a design card creation exercise in which the students were tasked with creating a design card based on the paper. Here I discuss findings for each of these exercises and then provide overall insights about creating exercises that engage designers with scientific publications.

### *Reading Guide*

I found that the active reading questions helped students better understand the scientific papers in a number of ways as well as countering the perspective that theory is not useful for design practitioners (Chapter 3, Norman 2010; Stolterman 2008). The exercise gave students a goal, making them more engaged with reading. I supported past work indicating that directives to read “critically” need to be coupled with tangible instructions for the reader as well as indicating how burdensome active reading can be (Shon 2015; Tashman and Edwards 2011; Yore et al. 2003). The prompts related to theoretical concepts and their connections to one another helped students break down the seemingly complex papers into building blocks. Becoming familiar with the building blocks of the theory enabled students to better understand theories as a whole. In addition, the request to summarize and explain a theory challenged students to imagine different components of the theory in a reflective and situated practice (Koutsabasis & Vosinakis 2012). This supports past work stating that simply paraphrasing can raise awareness of understanding gaps and transform ideas into familiar, more memorable ideas (McNamara et al. 2004).

Definitions and recommendations were the most valuable pieces of publications in our course. Therefore, I achieved a lower cost for a higher value in the activity by adopting organic strategies that I observed in the first evaluation.

My contribution is in finding what seems to be a good balance between time and scaffolding for an active reading guide that engages design classrooms with scientific publications. My exploration suggests that a more manageable active reading guide improved the learning experience. However, importantly, the guide that I used in the second evaluation was not significantly shorter. With iterative design I found an improved scaffolding and clearer guidance for my specific exercises, which made students spend less time doing the activity. It is also important to note that students themselves identified the value in following the prompts of my exercises and became more confident engaging with science as time went by. It seems to me that material constraints can help, which is also the view of instructors in the member-check process; they had positive experiences setting up time or material constraints (e.g., length of answer) for reading and writing exercises to engage students.

### *Card Creation Exercise*

The second activity was a card creation exercise. I found that the exercise encouraged students to understand theories, but foremost it allowed students to imagine how theories could inform design and research techniques. This opened up opportunities for critical thinking, creating bridges between theory and practice, and generating resources that can be revisited.

This exercise opened up opportunities for theories to be challenged, expanded, and adapted—the kind of critical thinking to be encouraged in HCI classrooms. Theories serve a specific purpose that is not to inform the work of designers (Yore et al. 2003). The difficult work is not only reading theory, but also envisioning its applicability and creatively translating it. Processing, synthesizing, and situating scientific knowledge can be overwhelming, but they are similar to the kinds of complex problems that UX/HCI professionals have to tackle in their practice (Stolterman 2008).

I found potential benefits in using an exercise like card creation for relating nuanced theoretical concepts to UX/HCI practice. Creating cards encouraged students to elevate their discussions about theory specificity to a practical level while imagining how to create design and research practice. It is particularly challenging to consider the potential applications of theory across multiple design scenarios. However, it opens up opportunities for critical thinking and novel understandings of theories. The instructors that I interviewed vehemently highlighted the value of encouraging students to think about the breakdowns of theories. They highlighted the value of asking generative questions that encourage students to draw on their expertise to explain how a theory is or is not applicable or how theories could be extended instead of acquiescing in the occasions when a student may dismiss the relevance of theories.

A side benefit of the card creation exercise was that it resulted in a set of resources that students can revisit later. Students invested time and effort in building their own repository of notes and cards, which incentivized engagement and learning, supporting past work (Adler et al. 1998; Hinckley et al. 2012; Osborne and Wittrock 1983; Schilit et al. 1998; Tashman and Edwards 2011b). Students stated that if

they ever had to refresh their memory about a theory they could reference the card decks, which they often shared with friends and coworkers. Collecting cards and annotations might provide an added incentive for designers and students to engage with science. This finding supports past work, positing that when readers themselves organize, review, and trace their extracted content back to its source, it increases learning outcomes and may facilitate recall as notes are organized following readers' viewpoints (Adler et al. 1998; Hinckley et al. 2012; Tashman and Edwards 2011b).

One of the most difficult aspects of this translation exercise was finding interesting and relatable design examples to situate scientific findings in the cards. However, as students noted, doing this was helpful, as it challenged them to consider the applicability of theories and supported prior work which found that examples generally improve the quality of ideas (Sio et al. 2015). One potential solution that I have explored is to allow students to create their original examples instead of relying solely on existing products, although this is yet another time-intensive activity, one which may not be in the scope of a theory class.

### *Integrating Individual Exercises with Group Activities*

While the two exercises were individual in nature, I found that they benefited from group-level engagements.

First, while attending to students' need to prepare for professional activities, students could practice self and peer explanation with the support of arguments found in scientific publications. Second, while listening to their peers' perspectives, students learned about potential applications of scientific insights and consider different viewpoints.

Through this work, I found how important students considered explaining ideas based in theories and clear arguments. Kreitzberg (2019) as well as Bybee (1995) and Hand et al. (2001) discuss how designers and other professionals must acquire skills to inform and persuade others—and modern organizations—to take action. It seems that becoming adept in explaining processes and ideas to colleagues coming from other disciplines can be particularly useful for HCI/UX professionals.

Influenced by McNamara et al.'s Self-Explanation Training (2004), I first emphasized self-explanation in the exercises and expanded exercises to the practice of peer-explanation as well. Self-explanations are important to correct misunderstandings of theoretical concepts individually before students have to expose their emerging knowledge to others. Explaining to oneself feels safer to students, giving them the chance to articulate their knowledge and identify gaps in understanding. Articulating knowledge at this early stage involves interweaving paraphrased theoretical concepts and annotations with additional thoughts based on students' experience and language, which is crucial for learning (McNamara et al. 2004; Osborne and Wittrock 1983). A potential drawback of self-explanation is that if students stop there they may remain with overlooked gaps in understanding.

I found that peer discussions can help to mitigate such danger while also demonstrating value in the context of learning theory. Peers not only expanded students' capabilities to identify when they had

misinterpreted information from the source text, but also collaboratively made sense of the readings in pairs, increasing their collective knowledge, access to information, and opportunities for healthy competition (Lewis 2013).

I specifically found value in pairing peers with diverse backgrounds to discuss theories, inciting richer perspectives and ideation of potential applications of theories. Having diverse backgrounds in the classroom and pairing diverse students is important for peers engaged in discussions to realistically place themselves in the shoes of varied audiences. I found that this encouraged students to consider different ways to interpret theories as well as diverse usability scenarios for design and research strategies. For instance, I had the opportunity to observe interesting discussions between engineers, designers, and psychologists about using theories for problem-solving or how design examples may or may not be supported by a specific theory. It cannot be understated how such diverse thinking informed by theories supports the objectives of understanding theory and how it can be used in design practice.

Finally, Yore (2003) mentioned that many of the strategies recommended in literature do not demonstrate the connections between improved presentation skills and understanding theory. I cannot establish such a relationship, although students mentioned that aptitude in crafting clear explanations and leading discussions are important skills in their day-to-day work, and they appreciated the opportunity to practice these skills, which can only be beneficial in learning theoretical concepts. Also, instructors must prepare for when students do not read texts or are disengaged, which limits the objectives of self- and peer-explanations.

### *Evaluating Exercises*

Within the context of these two exercises, I noted an interesting challenge for design instructors—how to provide appropriate feedback. Students desired feedback to know if they had a correct understanding of the reading and to make sure their cards were accurate. Instructors may also want to provide feedback to help students iterate on their materials. However, if these exercises required extensive review, they would then pose a heavy burden on the instructors, making them almost unimplementable. In the explorations described in this chapter, I found three important aspects related to providing feedback that have to be considered.

First, in the member-checking phase, I gathered what seemed to be different types of feedback: evaluative (when students' work was assessed as right/wrong), corrective (when students needed to correct their work), and grounded (connecting and discussing students' work with/through design examples). Instructors are particularly reluctant to give evaluative feedback in the context of theory reading and use, while ensuring that the feedback is appropriate, relevant, and sufficient (Wagner et al. 2002), as evaluating students' evolving knowledge on theory definitions or translated design artifacts cannot be evaluated as "right or wrong." It is equally difficult to provide appropriate feedback to students in highly interpretive tasks such as notetaking and self- and peer-explanation. Furthermore, corrective and grounded feedback take a lot of time depending on resources or class size. One way to mitigate this

challenge is peer feedback, but other students may also lack the expertise to provide corrective or grounded feedback.

Second, it is important to create a classroom culture in which students feel comfortable engaging without the pressure to “get things right all the time.” Asking students to highlight aspects of theories that they do not understand might make them feel unconfident. To deal with this, one instructor tells students, “it is okay not to know everything. It feels hard to read these materials...because it is hard” (DI1).

Third, I did not measure topic learning, but I gathered self-reported survey data that showed that students felt more competent in reading and understanding theories after the course (Figure 23). Although it is difficult to attribute these advances to the exercises, they certainly helped to build these skills. A recent panel of HCI researchers and practitioners on HCI discussed learning evaluation in HCI as an important path for research, with which I agree (Xie et al. 2019). In addition to practical grading problems, interdisciplinary HCI programs often gather students with different backgrounds and learning curves, which makes standard evaluation practices even more challenging.

## **Summary of Contributions**

The HCI academic community has translated and evaluated insights from multiple theories coming from other disciplines for decades. HCI findings can influence the work of practitioners, but as seen in Chapters 3 and 4, practitioners still face the translational barrier of applicability. As a response to this, I designed and evaluated exercises to guide HCI students to understand theories and how they can be used for problem-solving. Based on a classroom exploration with graduate students, I gathered insight for implementing engaging theory exercises in HCI classrooms. My findings suggest that students developed the skills to confidently read and understand scientific publications and to imagine how to use them to design, countering the dominant view that practitioners do not understand scientific terms or the value of scientific research.

Through this exploration, I offer four main findings. First, instructors interested in creating active reading exercises should invest in creating specific and clear reading guides, as students learning theories need a structured approach to navigate scientific publications to gain confidence. Also, summarizing and paraphrasing can help with theory internalization. It is also crucial to understand the material constraints of a sequence of exercises in light of the course context. Second, card creation exercises can help to show the applicability of theories to HCI/UX practice via critical thinking and creative translation, while also producing outcomes that students can keep, revisit, and share, which increases the incentive to engage. Third, I used both self- and peer-explanations to build students’ confidence and skills in explaining their ideas to others, especially ones from different disciplines—an important aspect of working in HCI/UX teams. Also, pairing diverse students increased learning opportunities and created ideation around theoretical application. Lastly, I found key aspects that have to be considered by instructors creating exercises with the goal of teaching HCI/UX students to read and translate theories. Providing appropriate feedback in this context is challenging. Acknowledging the difficulty of navigating theoretical resources

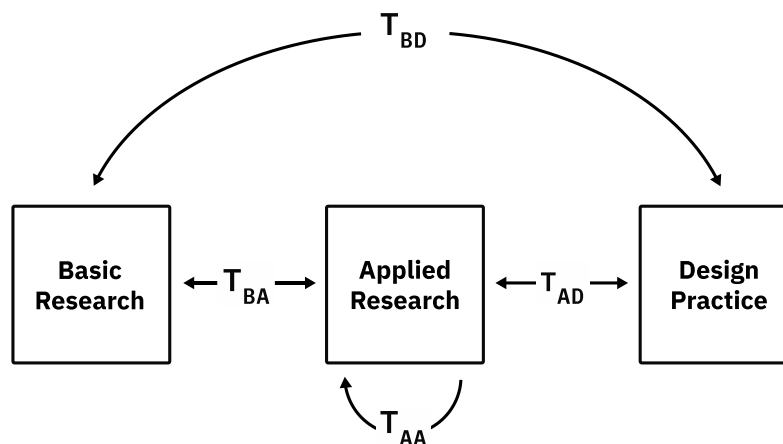
can help students to feel more at ease and willing to share. It can also reassure students that searching for the boundaries between right or wrong when exploring nuanced theories might be unrealistic.

HCI instructors who incorporate individual and group exercises into classes can take these findings further by adapting and expanding the proposed exercises to suit their needs and report their results and insights. In addition, more research is needed to understand the implications for designers beyond a classroom context. Finally, translating scientific findings and giving designers the tools to read and use science are both unidirectional approaches to the translational problem. There are many opportunities to rethink engagements between theory and practice in this context.

## Facilitating Application

As described in Chapters 3 and 4, many practitioners do not use academic findings in their research because they do not see the applicability of these findings to their work. However, as seen in Chapter 5, designers can read and understand theories as well as identify their value. Helping designers to read and understand theories is important but would also benefit from a structured process for envisioning how they apply to a given project or design brief. Since design practitioners think that real design constraints may undermine the “proper” application of theory (Gray et al. 2014), I asked,

“How to facilitate the use of scientific findings in the design process?”



**Figure 24. The Translational Science Model for HCI.**

To tackle this translational barrier, I iteratively created and assessed a novel design method, the Behavior Change Design Sprint (BCDS). I adapted Knapp et al.’s sprints (2016), originally crafted to be used by startups funded by Google Ventures, instead of creating an entirely new method. Design sprints are sequences of time-constrained design activities that lower barriers for participation. Sprints support an iterative design process and afford their use in a variety of contexts, with activities that can be performed by diverse stakeholders, promoting constructive and engaging discussions (Banfield et al. 2015; Knapp et

al. 2016). As regular sprints do not contain specific steps to incorporate theoretical concepts into the design process, I focused on creating and incorporating exercises that facilitate the use of theoretical concepts for prototype technologies.

BCDS was deployed and assessed in numerous workshops from 2017 to 2019. I found that the method helped design practitioners to brainstorm solutions based on theoretical concepts and to use these concepts to successfully explain design rationale.

To use BCDS, design teams need a few standard design materials such as personas and scenarios. If teams want to use the sprint for learning purposes, I provide sample design materials along with a step-by-step guide in a downloadable resource package.<sup>3</sup>

In this chapter, I first explain work related to behavioral change design and methods that can help to incorporate theory into the design process. Second, I explain how I created BCDS and study methodology. Finally, I report the results of the sprint assessments and discuss findings and main contributions.

## **Related Work**

User experience and interaction (UX/I) designers are often faced with the task of creating products and services intended to help people perform certain behaviors such as exercising more frequently or eating healthier (Barreto et al. 2013; Consolvo et al. 2009). This process of creating behavioral change technologies and designs is commonly referred to as Behavior Change Design (Fogg 1998; Hekler et al. 2013; Siegel and Beck 2014; Wendel 2013). Changing one's behavior is not easy, and behavioral change designs often fail (Norcross et al. 2002).

Design plays a growing role in improving people's lives as tools such as smartphones and the Internet expand the reach of products and services (Noar and Harrington 2012). Designers excel at creating aesthetically pleasing and usable products and services. However, designing to address problems with behavior requires another set of understanding than what is core to UX, interaction, and visual design.

However, despite the purported benefits of using behavioral theories and research for design, there continue to be gaps between theory and its application in practice (Gray et al. 2014; Hekler et al. 2013; Remy et al. 2015; Lindley et al. 2017)—most UX/I designers do not use resources that describe theories and their applications when designing (Chapter 4; Norman 2010). Research has found that one of the main reasons why practitioners do not incorporate theory into their design processes, despite being interested in doing so, is that academic findings are often presented in a way that is hard for practitioners to apply (Chapter 4; Gray et al. 2014; Norman 2010). For example, practitioners think that theories are often too abstract and that real-world constraints such as budgets undermine the “proper” application of theory (Gray et al. 2014). For more information on this key translational barrier, refer to Chapters 3 and 4.

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<sup>3</sup> Download the entire resource package at [lucascolusso.com/bcds](http://lucascolusso.com/bcds). I encourage interaction design, UX, and HCI researchers, lecturers, and practitioners to download, use, modify, and provide feedback on the materials.

In this context, design practitioners can leverage theories of human behavior to better understand people and how to nudge their actions through designs (Barreto et al. 2013). Design and HCI has explored the use of numerous behavioral change theories (BCT's) and offer design guidelines on how to use them (for example, Adams et al. 2015; *Behavior Change Techniques Taxonomy* by Michie et al. n.d.; Consolvo et al. 2009; Evans 2017; Michie et al. 2011; Noar and Harrington 2012). There are other efforts to digest and suggest the use of behavioral change theories coming from industry, such as the creation of design cards based on theories (Artefact Group 2017; Lockton 2013). Academics and practitioners have written books with recommendations based on Social Psychology and BCT's to communicate research. The book *Building Successful Online Communities* (Kraut and Resnick et al. 2012), for example, describes a set of actionable design claims supported with scientific evidence. Similarly, books labelled as “pop psych” (e.g., Ariely's *Predictably Irrational* 2008, Eyal's *Hooked* 2017, and Thaler and Sunstein's *Nudges* 2008) share academic work blended with personal industry experience.

While BCT's condensed into resources such as taxonomies, cards, and books can offer rich ideas for designs, instantiating research into an intervention is a difficult task, as theoretical constructs lack specificity for concrete design situations (Hekler et al. 2013; Remy et al. 2015). UX/I designers referencing these resources cannot find ways to fit theories into their process apart from “inspiration” (Chapter 4), and researchers say that theory instantiations produced by designers are often “wrong” (Norman 2010).

As an attempt to fill in this application gap, academics with a foot in industry—as well as practitioners—have created behavior change design frameworks. The most prominent frameworks were created by BJ Fogg, who published the eight-step design process and the Behavior Model for Persuasive Design (Fogg and Hraha 2010; Fogg 2009). Fogg's work guided the creation of other frameworks such as Wendel's “behavior change process” (Wendel 2013) and Eyal's “Hooked” guide (2014).

However, there are two major limitations with existing frameworks for facilitating behavioral change design. First, and more importantly, they fall short in providing designers a breadth of BCT's and explanations for how to use them. Second, these frameworks require the use of foreign terminology and exercises which may not be easily incorporated into designers' workflows, a known barrier for the adoption of new knowledge (Rogers 1995). From a scientific perspective, the authors of these frameworks do not show how the frameworks were evaluated, raising questions about their effectiveness. These frameworks again offer little to no guidance on how to use findings from behavioral change research.

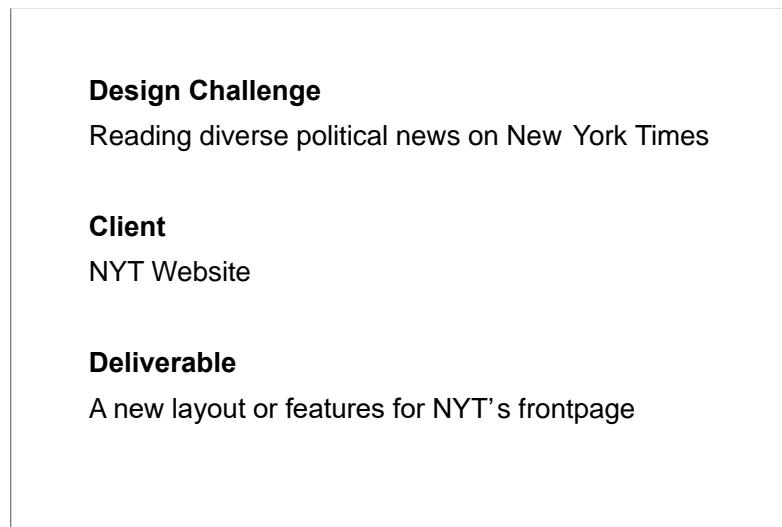
Therefore, in this work, I take a different approach. I modified a common design sprint format (Knapp et al. 2016), adding exercises to facilitate the use of insights from behavioral change. I drew on past work to guide the creation of a theory-driven sprint for designing behavioral change technologies: following past work (Huron et al. 2017), I refer to systems and artifacts developed to foster and assist behavioral change and sustainability as behavioral change technologies. For an extensive discussion on the controversies around this terminology, see Fogg 1998, Hekler et al. 2013, and Wendel 2013.

Supporting the application of BCT's for design may require processes that do not disrupt practitioners' workflows. Practice matters and adapting theories to designers' ways of thinking and doing is crucial. To

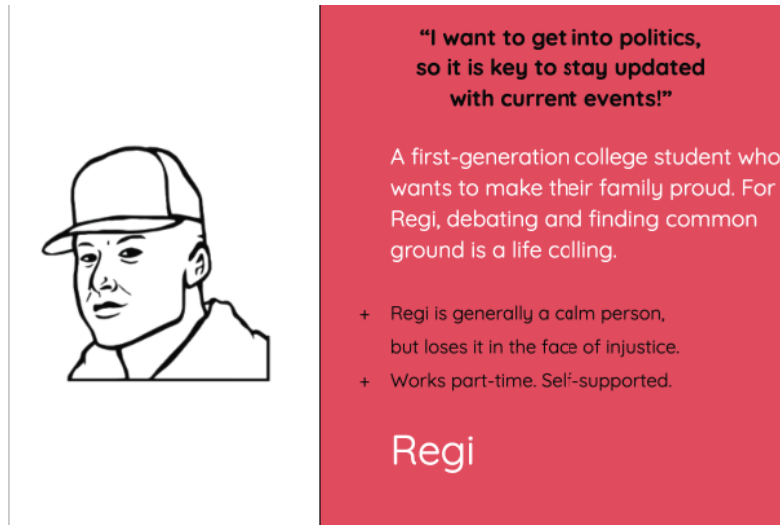
speed up the design process, sprints were adapted from programming practices (Schwaber 2004) and established as a key design method. Banfield focuses on the experience of agency designers working with both startups and established clients, and Knapp et al. capture the evolution of design sprints at Google (Knapp et al. 2016). Judging by discussions in online design forums and with fellow designers, a method such as Knapp et al.'s Design Sprint seems to be popular and a promising avenue for exploration.

## **The Sprint**

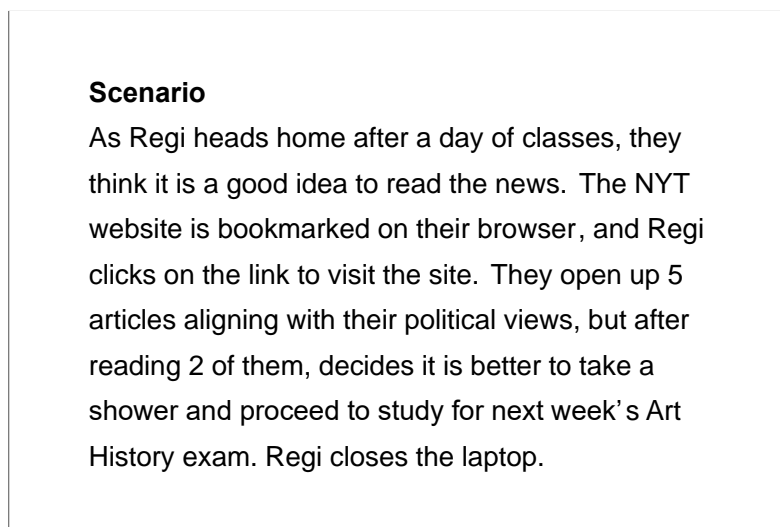
Before describing the steps in BCDS, I first explain what input materials are required. The sprint starts off with a problem statement framed as a design challenge, and the project briefing contains a design challenge, a client, and a deliverable. See an example of a briefing in Figure 25. Figure 26 shows the type of personas that I used based on recommendations from Cooper et al. (2014). Personas are a compelling material that can help design teams to rapidly engage and grasp the needs, experiences, behaviors, and goals of a user portrayal. Finally, Figure 27 shows an example persona-based scenario, which is a concise narrative account describing the persona's thought process and sequence of behaviors, rather than focusing on technology or business goals. See examples of these materials on the next three figures.



**Figure 25. Sprint briefing.**



**Figure 26. Personas.**



**Figure 27. Persona-based scenarios.**

The sprint lasts for 95 minutes and contains four steps based on Knapp et al.'s design sprints (2016): Map, Sketch, Decide, and Prototype, each with their own exercises (Table 11). Exercises in bold help to infuse BCT's into the design process. One important change was the removal of the final step from Knapp's sprints: Testing, which is a more complex and time-consuming task, falling outside of my scope to create a quick and easy way to apply theories into design. Timewise, the length of exercises is flexible and can be adapted according to how familiar exercises are to workshop participants.

**Table 11. The Four Behavior Change Design Sprint steps.**

1. Map	→	2. Sketch	→	3. Decide	→	4. Prototype
Understanding User Journey		Linking Brainstorming Sketching		Discussion Checklist		Design Annotation

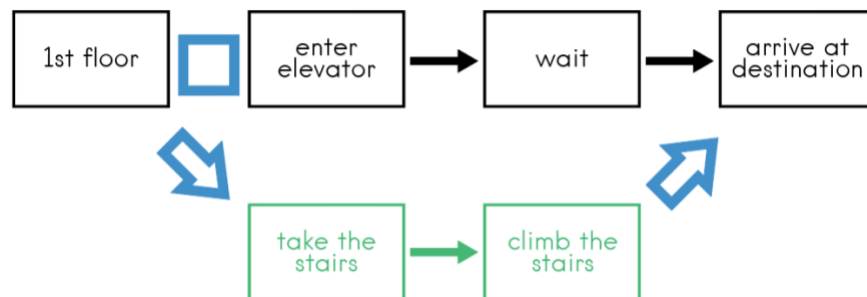
*Map*

In the first step, participants are tasked with understanding input materials and working on a user journey exercise.

In *Understanding* (individual exercise), participants define the sprint goals based on the constraints presented in the briefing, the persona, and the scenarios. Initially, participants read the materials individually and take notes about persona, scenario, and behavioral goals to be achieved via a design intervention.

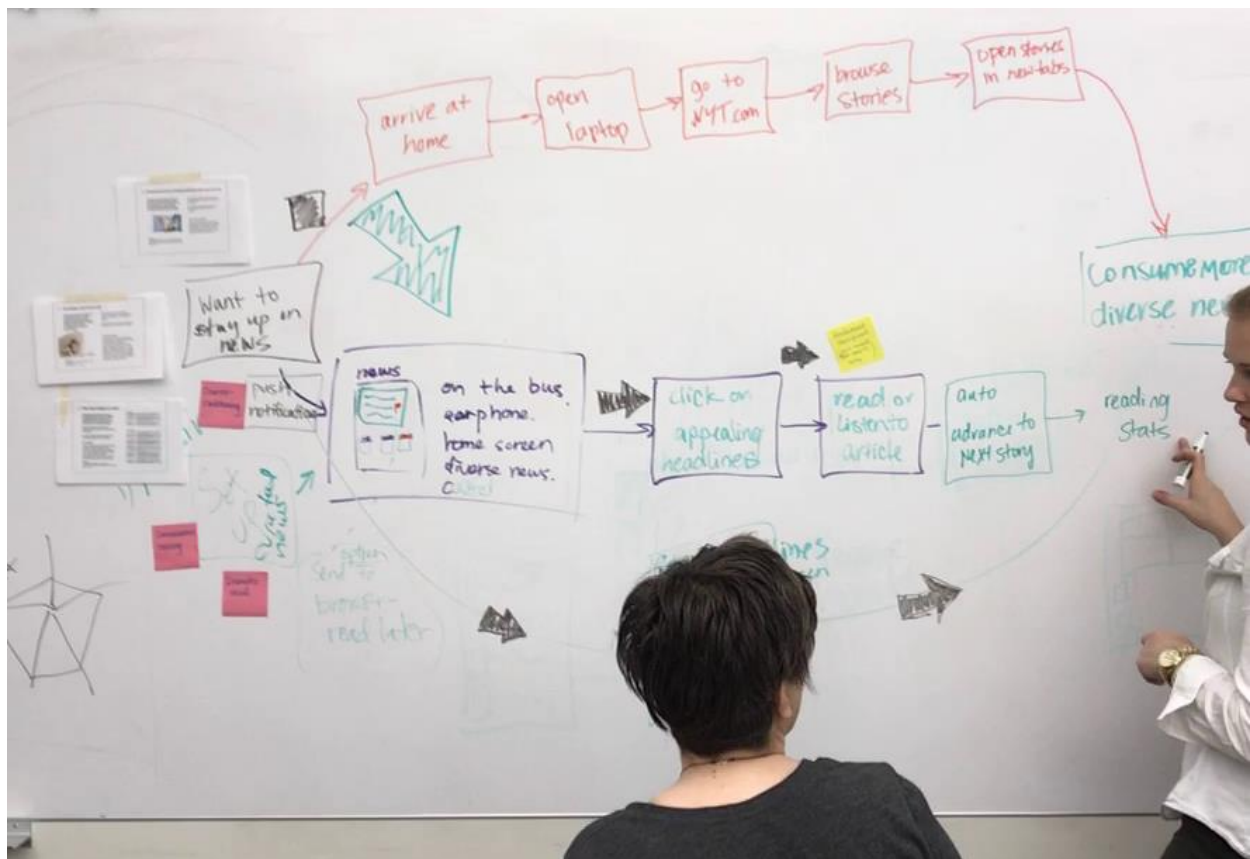
In *User Journey* (first tackled individually and then as a group), participants are encouraged to focus on the specific behavioral outcome presented in the challenge and to design interventions at the right time and location (Evans 2017). Participants convert textual scenarios into visual representations in the form of a diagram that is commonly called a “user journey.” Since persona-based scenarios are inherently concise narratives, they do not stress why personas perform certain actions or go into detail on the obstacles and triggers for personas’ actions in the narrative.

Regarding behavioral outcomes, participants transform the scenario into what I call the “current behavior path” (in black outlines in Figure 28), which shows the sequence of actions to be changed. Participants are then asked to create an alternative path in the flow, displaying the target behavior that personas would be encouraged to perform (in green boxes in Figure 28), informed by the design challenge (e.g., take the stairs instead of the elevator), making the target behavior a concrete and visible design goal. Participants also mark where interventions could work as nudges or obstacles in the flow.



**Figure 28. User journey example that I provided students as guidance.**

Finally, groups discuss and compare the user journeys generated by each group member. Participants combine their perspectives into one user journey, which is then drawn on the whiteboard, as recommended by Cooper et al. (2014). Hence, the user flow exercise helps participants to quickly visualize important behavioral aspects, and an agreed-upon diagram provides a solid setting for the steps that were yet to come (Fogg 1998). In Figure 29, see an example of how students engaged in discussions around the journey exercise. This scene was captured in the spring quarter of 2017 in a Human Centered Design and Engineering graduate-level course.



**Figure 29. Students discussing the journey that they defined as a team.**

## *Sketch*

In the second step, participants are given a strategy drawn from a BCT to explore, which I presented to participants with the form factor of a design card.<sup>4</sup> In *Linking* (group exercise), participants are asked to connect a strategy to particular locations of the user journey on the whiteboard. In the process, they must discuss cards and select those that they think are more useful to their current design challenge.

After linking cards to the user journey, the groups use the behavioral change techniques outlined in the cards as inspiration to brainstorm design interventions that could encourage personas to perform the target behaviors or put up barriers against performing undesired behaviors.

In *Sketching* (individual exercise), participants move on from brainstorming ideas to envision how to intervene on the user journey. Using prompts to influence sketching with a behavioral change perspective, I asked participants to sketch how potential design interventions could address the design challenge. The prompts focus on functional perspectives such as “Design an intervention to maximize the benefits of performing a certain action” and “Could someone else help the persona engage in behavioral change?” I wanted to incentivize designers to examine the ethical boundaries of behavior change design, prompting participants to explore extremes with prompts such as “Propose a design that would make people uncomfortable.” In addition, I provided more traditional prompts for designers to explore diverse solutions, such as “What would you create with technology from 100 years ago?” and “What would you create with tech that doesn’t exist yet?”

## *Decide*

In this penultimate step, participants present their sketches to each other and decide on one to prototype. Although Dow et al. (2010) suggested the benefits of parallel prototyping, for the rapid context of BCDS it was more appropriate to keep the amount of prototyping to a minimum. In *Discussion* (group exercise), the group is guided towards narrowing down their list of ideas and focusing on one single design from which to create a low-fidelity prototype. To guide decision-making, I provide a *Checklist* to prevent teams from prototyping ideas that do not address the behavioral change design challenge properly. The checklist has two parts. The first part contains behavioral change-informed prompts such as “How is your proposed design encouraging the ideal behavior? Or are you discouraging a negative behavior? How?” and “How is your proposed design connected to a behavioral change theory?” The second part reminds participants of the persona’s goals: “Is your proposed design appropriate to solve the persona’s needs and constraints?” and “How are you making it easier for the user to perform the ideal behavior?”

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4 Of note, BCDS participants can use the sample cards made available by the author with the rest of input materials or they can create their own cards. A suggested process to create cards is outlined in Chapter 4 of this dissertation. Sprint facilitators can also adapt other behavioral change-related cards to use, such as Artefact Group cards (2017) and Cognitive Biases cards by Dan Lockton (2013).

## Prototype

In this final step, participants generate a prototype of their proposed solution, including an explanation of how theory supports the proposed designs.

In *Design* (group activity), participants create a prototype to demonstrate how their proposed design intervention works. Participants are free to explore different design tools and levels of fidelity to present their concepts.

With *Annotation* (group activity), I emphasized advocacy, as it is suggested as a key design activity in Chapter 4, particularly one that designers have difficulty with. With support from the BCT's, participants annotate their work, explaining the rationale for design choices and how the design intervention is connected to a specific theory. Participants are prompted to reflect on the ethical implications of the designs they propose. I provide a template to support a quick turnaround of the sprint deliverable (Figure 30). The template contains a summary of the design, the user journey, and an annotated design prototype.

## Methods

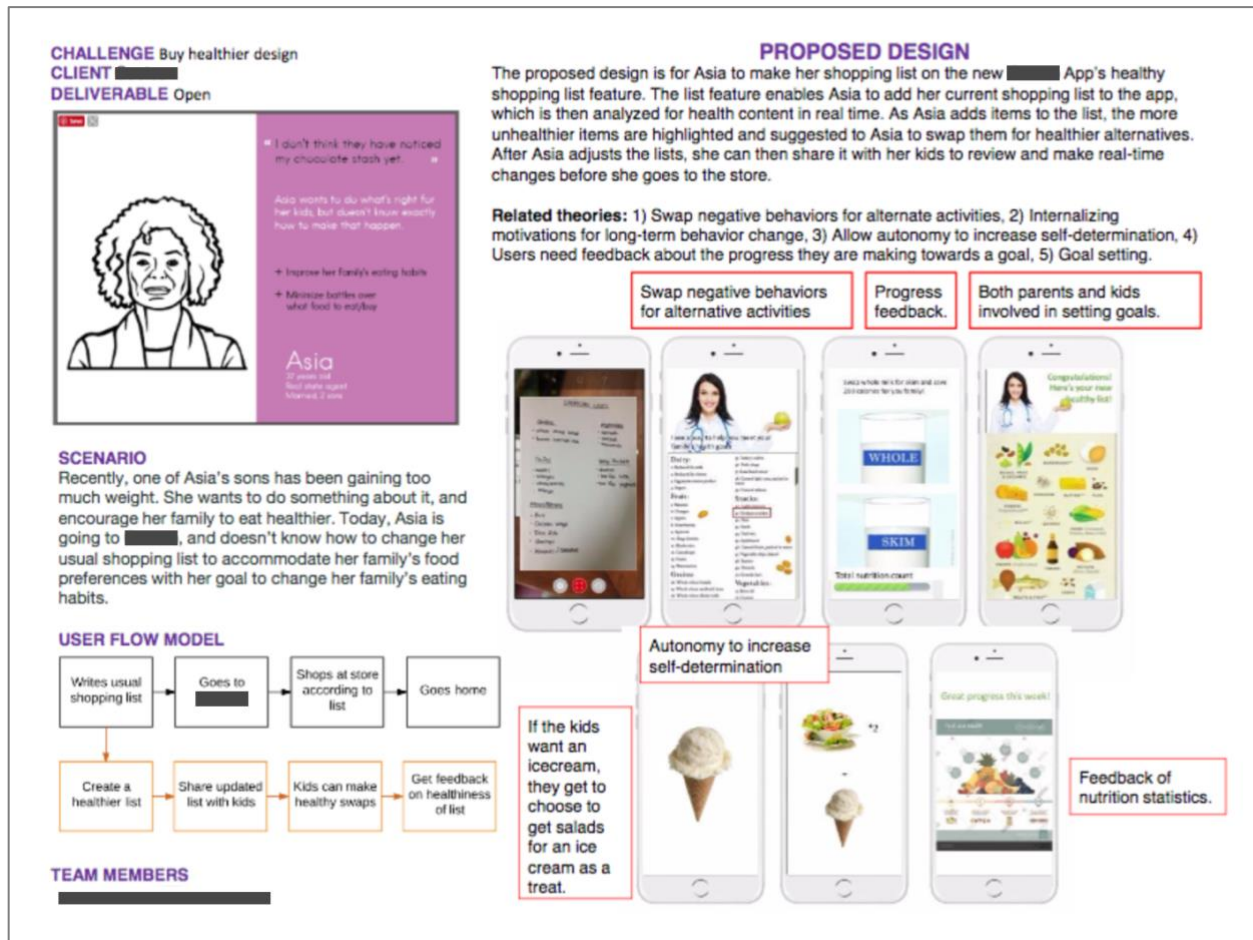


Figure 30. Sprint deliverable template.

Although I have been deploying the sprint for many years, in this Chapter I report only the results of a series of seven sprint sessions: five with human-centered design master’s students, one with high schoolers, and one with professional designers from a large tech company. I present data from these seven sessions, as they were the initial set of evaluations that I conducted and reported on a published paper about the method. Later sessions were formally evaluated for other work, such as the one presented on Chapter 5. Participants’ experience with design or reading BCT’s varied (Table 12). “P” is used for interviewees, “S” for survey respondents, and “T” for participants of our last deployment in a tech company. See the Appendix for more details on study participants.

**Table 12. BCDS evaluation participants.**

<b>Participants</b>	<b>Design</b>	<b>Behavior Change theory</b>
<b>High school—7 total</b>	Little to no experience	No experience
<b>Master’s (P, S)—18 total</b>	3 advanced 6 intermediates 5 novices 4 no experience	7 no experience 6 novice 4 intermediate 1 advanced
<b>Tech (T)—3 total</b>	Avg. 9 years of experience	1 novice 1 intermediate 1 advanced

I first used the sprint in a master’s course in the second quarter of 2017 in my academic department. I also tested the realism of the sprint in other contexts, such as with a group of high school students during a summer camp in 2017. The deployment with high school students was less constrained—personas, challenges, and clients were not used. That same summer, the design sprint was used by three professional industry designers at a large American technology company. I tailored inputs to the design challenges that these professionals faced at work and only removed personas after they mentioned disliking the use of such design material.

In all workshop sessions, participants were split into small groups of three to four, combining design, development, and research skills. I alternated between individual and group exercises to enable individual creativity but also to help participants build on each other’s ideas (Dow et al. 2010).

Each week, the students were given a different design sprint briefing and a card based on theory. Table 13 shows the list of theories that we used in the course. Each card focused on a single insight from a BCT, containing a short and prescriptive title, a figure that was meant to exemplify a theory instantiation or a theoretical model, and a short paragraph explaining how the theoretical insights and instantiation are connected. The card also showed a reference to the particular publication that outlined the BCT at hand. These features were based on recommendations from Chapter 4.

**Table 13. Behavior Change Theories used as a reference in the sprints.**

<b>Theory</b>	<b>Summary</b>
Goal Setting (Locke and Latham 2002)	Setting clear goals will motivate people to actually achieving their goals.
Health Belief Model (Champion and Skinner 2008)	Attitudes and beliefs of individuals predict their health behaviors.
Intrinsic and Extrinsic Motivations, Incentives (Hsieh and Kocielnik 2016; Ryan and Deci 2000)	Intrinsic: doing something because it is enjoyable. Extrinsic: doing something because of the outcome.
Social Cognitive Theory (Luszczynska, Ralf Schwarzer 2005)	Having a sense of self control and forethought motivates behavioral change
Social Comparison (Colusso et al. 2016)	Closeness to comparison to improve performance feedback.
Target Behaviors (Fogg and Hreha 2010)	Matching target behaviors with solutions to achieve the behavioral change.
Theory of Planned Behavior (Ajzen 2012, Davis et al. 2002).	Predicting deliberate behavior through intention.
Transtheoretical Model—Stages of Change (Procheska et al. 2008).	Health behavior change through six stages of change: pre-contemplation, contemplation, preparation, action, maintenance, and termination.

Most data come from the five sessions with master’s students. Students were invited to take surveys throughout the course: once at the beginning, another midterm, and once at the end. Not all students answered the surveys. After the course ended and grades were submitted, students were invited to participate in an interview.

I conducted, audio recorded, and transcribed ten interviews (over 13 hours of content). In the other two contexts (with high schoolers and professional designers), field notes and informal dialogues with participants were catalogued. During each sprint, I observed how participants used materials to discuss ideas, collaborate, and generate designs. After each sprint, the sprint format was revised and tweaked by the research team.<sup>5</sup> Two researchers open coded raw interview transcripts, field notes, and survey answers with the patterns to gather important aspects of the sprint.

## **Findings**

I found that BCDS overall facilitated the application of BCT’s into the design process ( $T_{BD}$ ). The method seems useful for designers looking for ways to quickly and easily incorporate behavioral theories

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<sup>5</sup> The courses were led by Professor Gary Hsieh and assisted by the author of this dissertation. The research team was completed by a graduate student who helped to conduct data analysis.

into their work as well as for researchers interested in disseminating their research outcomes to practitioners or in translating behavioral theories for their own applied research ( $T_{BA}$ ). Based on the findings, I discuss the breakdowns of what I distinguish as unique aspects of behavioral change design.

First, in general, participants said that theories helped to “frame their thinking.” For [I4]:

I would definitely rely on theory to mold my thought like, if I’m designing something for behavioral change, I would definitely go back and look at like what are the stages of change, what in our product fall into this stage, how do we want to attack this.

Second, S15 thinks that theories develop design instinct:

As UX professionals we are in the business of facilitating people’s lives and behavioral theory seeks to understand how humans behave. This can give us better instinct when approaching problems and help us to form better assumptions which we inevitably bring into our work.

Third, some participants described how using theories brought more certainty to the design process:

I think that using academic theories in sprints can cut a lot of the guesswork out initially and help scope down and formulate ideas better because we have a better understanding of users. (I3)

Below, I describe how the exercises supported, or did not support, design.

### *User Journey Helped to Ideate Specific Behavior Outcomes and to Consider Time and Location of Interventions*

“Having the flow helped us be like, okay, what do we actually want to do, what’s going to be more effective? What is our goal?” [I8]. Three participants drew a funnel, showing the proportion of “users” who would be left behind or encouraged to change their behavior after their design interventions came into play. The “funnel” also spurred a conversation about behavior measurement. One participant said:

It took me a while to get experimental design and how it affects my work. It took a lot of talking with data scientists. This exercise helps to design for an exact consequence so nicely. I wish I was taught this earlier in my career. [T3]

Participants also said that the user journey helped them identify where and when to position interventions. Participants could glance at the diagram and collaboratively imagine how to intervene during particular steps of the story. “The user flow sort of broke down the bare scenario into the workable components of the flow and so then you could surgically say where your design was stepping in,” [P6], where a “nudge might be more appropriate” [I9].

However, I found that the user journey exercise did not sufficiently support thinking about why the personas would perform an action or their motivations to do so. Since scenarios are extremely concise,

they do not focus on why personas perform certain actions or go into detail on obstacles or triggers for personas' actions. Nevertheless, I observed that participants never asked for more details on persona motivations or scenario details. Participants were biased for action and quickly took design constraints without questioning.

### *Design Cards Acted as Reminders of Theories and Encouraged Focused Brainstorming*

Participants mentioned that theory was useful in the brainstorming exercise when it added new perspectives, served as reminders, and helped them to focus their brainstorming. “It makes you think outside of the box for a solution that may not have been your first instinct” [I9], and supports having “better ideas” [I7]. For some participants with experience reading behavioral change literature, using theory cards at this stage reminded them of what they already knew [I1, I3, T2]. Participants said that cards (Figure 13) helped them to narrow down which aspect of the design to address in the brainstorming [I4, I6, I8].

### *Specific Examples Were Useful for Sketching Interventions*

In general, participants mentioned that cards could have more applied examples such as “of companies and products that did successful behavior change design” (I4) or “more updated work in the current context (not sixties’ or seventies’ theories)” (I10), showing a sense that theories may be out of date or simply an inclination to dismiss them as out of date. Half of the interviewees specifically mentioned (without being prompted) that the card about Self-Determination Theory was “applicable” (see the card in Figure 31) because it exemplified two specific constructs (competency and autonomy) using a well-known tax return application. It is unclear whether the original designers of the tax application were influenced by Self-Determination Theory. This finding suggests that to facilitate sketching exercises, participants asked for contemporary design examples from applied contexts related to common design challenges rather than studying results based on “offline” scientific experiments.

# 05

## Make users feel competent and autonomous when completing mundane tasks

For a high level of intrinsic motivation people must experience satisfaction of the needs both for competence and autonomy. People need to feel capable in completing their task and feel in control of their intended outcome.

### Reference

Ryan, Richard M., Deci, Edward L., (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions, University of Rochester.

### Design questions

How might we make boring tasks more interesting?  
How might we motivate users to accomplish mundane and routine tasks?

### Example

TurboTax turned the task of filing taxes from a boring hassle to a simplified and streamlined process. In doing so, more users felt competent in filing taxes while eliminating the need for an accountant or tax professional. In turn, users had complete autonomy in driving their intended outcome.

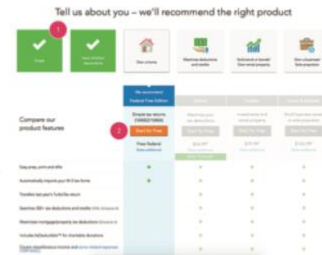


Figure 31. Design strategy informed by Self-Determination Theory.

### Theories Facilitated Explaining the Design Rationale Behind Proposed Interventions

Participants found that using theory to defend design rationale was effective and helped them to “articulate design intent” [I10]: “It gave us a good starting point to even start annotating. It helps your dialogue and it helps you form your thoughts and articulate them in a better way” [I2]. In addition, S5 said that the sprint taught her to “think more about each design choice,” a sentiment that was shared by most participants. Participants seemed inspired by the exercise and expressed an interest in using theories in their professional work to support reasoning [I4], defending [S12] or justifying a design [S1,S2], or even to sound smart [S11]. S6 illustrates this with a real account: “I’ve tried to bring theories into my design reviews at work. So far it’s been well received, especially if I start with context and then cite empirical evidence and can relate it to our business context.”

### The Ethics of Behavioral Change Design

Although I created prompts to spur conversations on behavioral change ethics during the sprint, ethics tended to be overlooked by participants who were rushing to design a prototype. On the other hand, in the interviews I understood that the sprint led participants to consider ethics as a crucial aspect of behavioral change design.

I think that's really the challenge with behavior change, deep rooted habits are harder to uproot if you're addressing them so directly because it almost feels like the person is being shamed into changing. [I4]

The focus is on explicitly leveraging psychology to a user interface's advantage, which sadly encourages the design of dark patterns. I'd like an ethics class devoted to that. [I10]

I believe that ethics needs to be made more salient in the process, and I discuss possible ways to do so in the next section.

## Discussion

Based on the findings, I now discuss how the sprint facilitates translation. In general, I found that the sprint facilitated the application of behavioral change theories into design practice. In Chapter 3, I labeled such knowledge translation path as “T<sub>BD</sub>.” For the reader interested in understanding how successful or unsuccessful specific steps of the sprint were, please refer to the full published paper about BCDS<sup>6</sup>. Here, I put forward a discussion of how Translational Research methods or tools can be designed based on what I found by using the sprint. In the remainder of this section, I describe opportunities and challenges for translational researchers interested in designing tools to bridge basic research and design practice.

Importantly, instead of creating and testing translational resources with different framings of scientific findings, I focused on helping designers to incorporate existing resources into the design process. This approach was directly informed by the findings presented in Chapters 3 and 4, where I discovered firsthand how critical the applicability barrier is in Translational Research and the need for resources that fit into practitioners' workflow.

### *Tooling Critical Reflection into the Use of Academic Findings*

The goal of the Map step in BCDS is to help designers understand input materials such as briefing, personas, and scenarios. I quickly noticed that since designers are not commonly trained in how to translate a theory-driven recommendation, they often resort to common exercises such as brainstorming. However, my evaluations suggest the need to set up a design process, drawing on designer's practices and terminology, that aligns with the objectives of Translational Research.

In particular, the theory-driven *Journey* exercise showed itself to be valuable. In this exercise, sprint participants read textual design scenarios and turned them into a diagram. All participants said that it was helpful to translate the scenarios into diagrams because they made scenarios more tangible and easier to discuss in groups. Most importantly, participants used the *Journey* exercise as a springboard for connecting theories to the design scenario. Doing so promoted agreement and convergence, which are commonly lacking in brainstorming sessions (Cooper et al. 2014). Past work (Huron et al. 2017) also

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<sup>6</sup> Lucas Colusso, Do, T., & Hsieh, G. (2018, June). Behavior Change Design Sprints. In *Proceedings of the 2018 Designing Interactive Systems Conference* (pp. 791–803).

mentions participants getting stuck at the ideation phases of the design process and discussing concepts for too long—a critical pitfall in collective and rapid design workshops. I did not encounter this issue with participants in my sprint sessions. Participants always quickly brainstormed as a team.

However, it seemed that the *Journey* exercise fixated participants' design thinking on designing to encourage activity rather than reflecting on personas' motivations to perform actions. Although designing to encourage particular habits and routines is valuable, there are opportunities to help designers think in more depth about the motivations behind people's behaviors (Siegel and Beck 2014). Understanding why behaviors occur and how designers can tap into or dissuade those motivations is key to designing behavioral change (Evans 2017). Potential improvements to this step include encouraging participants to question the input materials and to investigate lacking or implicit information on behaviors related to the design challenge through quick and informal user research. Another idea is to invite a user to codesign potential interventions, adding realism to the sprint. Alternatively, participants themselves could engage in roleplay.

I also imagined other ways that theory may help designers to further understand the context of a design challenge, beyond what I did in the sprint. As mentioned above, there are opportunities to help designers to understand why behaviors occur, which is key to designing behavioral change (Evans 2017). For example, ethnography results may not provide specific design implications or strategies (Dourish 2006) but could potentially be translated into personas, models, or vignettes representing scenarios, materials which could also be used as input materials in the sprint. Another example would be to integrate a root-cause analysis into the sprint format. More studies should be done to understand how such materials and different types of HCI knowledge can help designers apply scientific findings in their work, furthering the exploration of T<sub>BD</sub> knowledge transmissions.

In the Decide step of the sprint, I tried to inspire group discussions with checklist item questions for discussion related to behavioral change theories and ethics. The checklist that I provided did not directly help, as participants rarely used it. Instead, participants suggested that the checklist questions should be considered as guiding questions and used throughout the entire sprint. I imagine that ethics heuristics could exist as recurring incursions during the sprint or in sprint iterations.

In the last step, the overall goal was to encourage designers to practice advocacy (a key design activity according to findings from Chapter 4 and one that designed practitioners struggle with, as seen in Chapter 3), which participants said were helpful in supporting design advocacy. Participants confidently defended their design rationales by breaking down components in their design to justify using theory. It is unclear if the feeling of certainty was influenced by the newly discovered ability to leverage theory to back up design decisions. More work is required to understand the relationship between using theory for design advocacy and its impact on other design activities. I acknowledge that my participants did not have to advocate for these designs in a real-world context, so I do not know whether the reported confidence would carry over.

In terms of the ethical discussions around the behavioral change topic, my preliminary attempts at including such aspects in the design process were mostly unsuccessful. Most of the ethics-related prompts

were placed at the end of the sprint, as I imagined that it would be easier for students to explore ethical limitations of a tangible idea. However, as I proposed participants to tackle a design challenge in a rapid design workshop, participants may have become more interested in “solving” the challenge than necessarily reflecting on how theories were underpinning their choices as they were close to completing the sprint. This was a clear impact of the forcing function of timing constraints but also speaks to the more general pragmatism of design practices. A secondary goal was educating designers to become responsible translators of theory—especially in the context of behavioral change. I noticed a few opportunities to make such efforts more central to the sprint. There are additional opportunities to create space for ethical discussions in the collective *User Journey* exercise. As outlined previously, participants should be more aware of human motivations for taking action in the user journey. Therefore, that exercise seems to be a promising channel to explain terminology and practices that leverage design theories to avoid the generation of coercive design concepts. Finally, the *Sketching* and *Checklist* exercises are areas where ethical considerations can be explored at different capacities and possibly in creative ways (e.g., in *Sketching*, asking participants to design a coercive artifact, which then is used in a follow-up discussion).

Taken together, these findings provoke the HCI community to think about ways to create more reflective exercises, more ethical discussions, and more in-depth explorations of context and motivations, as well as challenging and expanding theories.

### *Quickly Generating Testable Prototypes Based on Academic Findings*

The sprint was useful for quickly translating theories into prototypes. In the first step, participants created a hypothesis and identified specific timing and placement for interventions in conformity to the user journey. Then, in the second step, participants drew on the journey and theory-driven design strategies to brainstorm ideas for interventions. I will now discuss how these two steps supported the creation of prototypes.

First, the *User Journey* exercise facilitated devising interventions that could support specific behavioral outcomes as well as identifying specific moments and locations to deliver interventions.

Participants said that, in general, leveraging theories helped them to make more certain and confident decisions on what ideas to invest time in and, ultimately, to prototype. Interestingly, the exercise made designers effortlessly plan somewhat advanced experimental conditions to affect human behavior (one participant related the exercise to causality—if [design] is used, then [outcome] happens). As such, the exercise spurred group conversations about behavior measurement. These findings open up interesting areas for exploration such as using the *User Journey* exercise to educate designers on notions of experimental design (Hekler et al. 2013) or even supporting the work of HCI researchers working on T<sub>BA</sub>, for example.

The *User Journey* exercise also helped participants to identify how to deliver interventions to personas. To impact personas’ daily routines, past work has described “time” and “place” as critical aspects in designing effective change triggers (Evans 2017), as, over time, people link specific parts of their routines with actions through the creation of if-then scenarios (e.g., “whenever I enter the building, I

take the stairs”) (Bayer et al. 2009), thus supporting the habit formation (Ornelas et al. 2015). With the diagram, participants could easily visualize the most effective change triggers in terms of time and place, considering the context presented in the scenario.

Second, the inclusion of theory was an attempt to bridge  $T_{BD}$ , particularly considering the understanding and applicability barriers. As much as participants mentioned that theory cards helped them to brainstorm ideas that were aligned with the theories being used in the sprint, they also mentioned that they often lacked “good examples” of designs informed by theory. In addition, influencing expressive and sometimes unconventional approaches to sketching is inherently difficult because there is a natural disconnect between what scientific research offers as an output and what a designer wants to produce—usually a tangible design idea. These findings also elaborate on findings in Chapter 3, as I found particular types of examples to be important for sketching.

To address the lack of ‘designerly’ examples in scientific research, translational resources may need examples of theory instantiations in current products or even stories of products that may have been influenced by academic research.

First, participants asked for more updated examples from applied contexts related to their daily design challenges rather than studying results based on decades-old offline experiments (the age of some theories in the behavioral change cards). This is an interesting finding, as it indicates an interest by design practitioners not only in basic research findings ( $T_{BD}$ ), but also in applied research findings. Therefore, more work should be done to assess the usefulness of the sprint for  $T_{AD}$ —or perhaps a joint approach to tackle  $T_{BD}$  and  $T_{AD}$  simultaneously. Nevertheless, designers think that research findings are distant from the “real problems” they face (Norman 2010), such as the ones my participants mentioned—getting users to try new features and getting users to maintain a “one-time behavior” (more examples were found in my study presented in Chapter 4: increasing time spent on an app, increasing sign up or check out rates, and increasing comments). Or perhaps theoretical papers are more generalizable (and thus more flexible) than applied papers, and so they often work better for designers than applied papers, even if designers think they want more examples from applied work.

Second, I believe that stories of how real design teams leveraged scientific findings to build products or successful companies could be powerful—for example, accessibility research and the iPhone screen reader (Ladner 2014; the relationships between Ubit and Fitbit that I discussed in the introduction). It seems that even if academics are not completely confident of the links between specific scientific findings and a product or a service, such stories could still be a powerful way to communicate concepts that designers can understand and apply to their context. Researchers may be concerned with reputational damage if they appear to take credit for innovations that were produced in parallel by practitioners. The implicit challenge here is to learn how to discuss theory-product connections in a sensible, precise way while establishing important boundaries of authorship, theory nuance, and others. This could also be approached from another angle, with stories of products or services that do not implement scientific findings, along with discussions of how they could be better, or at least different.

Finally, to further support the prototyping of designs based on theories, I imagine that behavioral change theories can be factored into design patterns containing tangible parts that designers can use, such as wireframes or code snippets (Chapter 4). This is an exciting area for HCI researchers to explore, following the example of information visualization findings that are translated into actionable libraries (Vega n.d.) and even industry design pattern libraries such as UI-patterns.com, iOS, and Material design guidelines (Toxboe n.d.; Apple n.d.; Google n.d.).

## Summary of Contributions

This chapter offered two main types of contributions. First, I explained the steps of a new design method: the Behavior Change Design Sprint (BCDS). BCDS can be used for applying behavioral change theories in the design process, helping designers to quickly generate ideas for behavioral change technologies. Second, evaluating the sprint allowed me to explore advanced Translational Research issues that relate to the dissertation as a whole. I found interesting considerations for the design of translational resources and tools that tackle the applicability barrier, referenced as a key translational barrier in the HCI Translational Science Model (Chapter 3).

First, I discussed the benefits of the sprint for encouraging critical reflection in Translational Research. Theory can support understanding rich and nuanced design spaces when it is used to engage designers in the planning of a Translational Research scenario. By helping participants to translate the scenarios into diagrams, abstract scenarios were made tangible and easier to discuss in groups. However, the *User Journey* exercise fixated participants' design thinking on designing to encourage activity rather than reflecting on personas' motivations to perform behaviors. This is a clear impact of the forcing function of timing constraints.

In addition, participants appeared to become more confident defending design rationales using theoretical concepts, supporting the same findings from Chapters 4 and 5. In turn, I had challenges with how to approach and effectively incorporate deep ethical considerations in the sprint. This seems to be a promising channel to explain terminology and practices, leveraging theories to avoid the generation of coercive design concepts. I envision other ways in which theory can be infused in the sprint. For example, ethnography results may not provide specific design implications or strategies, but they could certainly be translated in personas, models, or vignettes representing scenarios, materials which could also be used as input materials in the sprint.

Second, BCDS helped designers of varying experience levels to quickly generate design interventions that map into theoretical constructs. Findings suggest that the rapid workshop can enable the application of theoretical concepts for the creation of prototypes that can be further tested. Participants created hypotheses, dabbled in experimental design concepts, and identified specific timings and placements for interventions in conformity with the user journey. Participants said that, in general, leveraging theories helped them to make more confident decisions on what ideas to invest time in and, ultimately, to prototype. In this ideation process, participants perceived the obvious lack of 'designerly' examples in scientific research, which could be approached in different ways, with examples of theory instantiations in

current products or even stories of products that may have been influenced by academic research. More information on this topic can be found in Chapter 4.

Overall, this project explored how to tackle the applicability barrier at play in Translational Research in HCI. This effort encourages the HCI field to think about the applicability and adoption of scientific findings by design practitioners not only as helping to design something, but also to influence and structure how designers think about problems, the discussions between designers, how they design things, and how designers explain their ideas. Such findings are important, as they suggest important features that should be considered when designing bridging strategies for  $T_{BD}$ .

## Discussion

The studies I presented in this dissertation responded to issues arising from the research-practice gap metaphor and recast the translational problem in HCI as one of Translational Research. In this chapter, I elaborate on how the contributions of this dissertation advance Translational Research in HCI in terms of both understanding and execution. I also discuss opportunities for future work in the space.

Before diving into the contributions of this work, I highlight one insight I have gained in performing translational work: Human-Centered Design (HCD) can serve as a guide for translational projects, although those interested in using HCD for translational projects should consider a few observations based on my experiences. Foremost, it is critical to consider that translational work is a continuum of interdisciplinary activities – it *depends* on diverse partners and what they can do for a translation. Although important in HCD, such consideration is likely even more crucial in the context of Translational Research. The overall project strategy should be based on deep understanding and participation of partners – not only end-users – and their knowledge, needs, preferences, and limitations. For example, activities such as sketching, brainstorming, rapid usability testing may be entirely new to partners – but who come with their own expertise that can also be valuable and need to be garnered. Another example is the necessity to obtain realistic time and resource commitments. It is common for translational groups to have partial dedication to a translational project. For example, when working with universities, translational groups need to acknowledge the difficulty to reach academics at the start or end of terms; when working with for-profit organizations, consider the way they budget and plan projects; and so on. More work is needed to understand how to appropriately coordinate and entangle interdisciplinary knowledge for the purpose of Translational Research in HCI.

I now will summarize how the contributions of this dissertation advance Translational Research in HCI in terms of specific steps for doing translational work using the HCD process as a backdrop.

The most basic HCD challenge is to understand and define stakeholders' needs. Contributions in **Chapters 3 and 4** bring more clarity and precision to translational problems and their associated gaps (Ts), highlighting unique challenges across specific gaps and supporting scoping strategies for the complex interdisciplinary work to harvest the insights of academic scholarship and lead to public gains. Specifically, during problem setting, we can utilize the Translational Science Model for HCI to identify

gaps in which they are working, and the key barriers present in those gaps. This work will also help to identify target users and stakeholders that may not have been identified earlier in traditional stakeholder analysis. I also contribute with tools for identifying target users' practical informational needs. Guidance in **Chapters 3 and 4** – specifically the Taxonomy of Translational Resources – serves to identify design activities that can be informed by different translational resources. These contributions can aid translational groups in defining decisions to be made, the ends to be achieved, and the means that may be chosen to achieve such ends (Schon 1984).

The next step is designing resources to aid in translational work or translations themselves. From my experienced, I learned that first, it seems crucial to identify *what* to translate and then to facilitate the *understanding* of such knowledge among the diverse individuals involved in a translational project. Considering the interdisciplinarity of translational groups, although some group members will be domain experts, it is important for the group to share common understandings of the scientific research at use. **Chapter 5** of this dissertation provides guidance to facilitate the understanding of scientific theories within groups, being them academic or nonacademic readers of science. More investigations are needed on prioritization of knowledge, packaging, and understanding scientific research in collaborative and interdisciplinary groups tackling real translational projects. Second, once the body of knowledge and target audience are identified and understood, partners should direct their attention to defining how to translate knowledge. This step often depends on the experience of a group with translational projects, while leveraging expertise with design, engineering, and marketing in tasks such as creating and building messages, products, and services. To facilitate such tasks, in **Chapter 4** I offer a taxonomy of types of resources that inform specific design activities; hence if a translation's target users are HCI practitioners, translational groups can use the taxonomy as reference for creating translational resources that fit into current design workflows. In addition, to effectively develop translations of knowledge, translational groups can use the Behavior Change Design Sprint (BCDS) that I contributed on **Chapter 6**. BCDS has demonstrated promise to facilitate low-cost translation of behavioral theories into prototypes of digital products or services.

There are other steps in a translational project, such as dissemination, evaluating outcomes and stabilizing a translation. These steps are all ripe for future research.

Finally, I do not suggest that everyone in the HCI community will become an expert in translational work, but rather that they can develop a sensitivity to the value and opportunities inherent to the process. To facilitate Translational Research in HCI, members of the community will benefit from my contributions for understanding the translational process and how to do translational work. In the remaining of this segment, I dive deeper into each contribution made by my dissertation research.

### **Empirical Contribution One: Understanding the Barriers in HCI Translations**

A widely cited article in the HCI field is Rogers (2004), a 16-year-old opinion article that explains that the gap between research and practice is not a new concern in HCI. Four years after Rogers' article, Stolterman (2008) argued that the gap could be explained by a lack of understanding of design practice

among academics who developed design theories and methods of practice. Since then, insightful work has been done in understanding design practice—see Goodman et al. (2011), Gray et al. (2014), and Schønheyder & Nordby (2018), and in framing the research-practice gap, see Beck & Ekbia (2018), Buie et al. (2013), and Roedl & Stolterman (2013). Such work contributed to discussions about what separates academia and practice, especially the barriers standing between them.

In contrast, part of my dissertation work focused on gathering empirical evidence of the barriers for academic scholarship to support HCI practitioners’ work. I contribute an updated list of the most important barriers that inhibit the use of academic resources in HCI practice. Contrary to popular belief, I found that HCI practitioners do value insights coming from academic researchers, especially when topics overlap with their work and interests. However, few HCI practitioners in my dissertation mentioned using peer-reviewed, scientific research to inform their work. My participants affirmed that the language of academic publications can undermine their ability and interest in reading and understanding science. Practitioners mentioned that reading academic research is complicated, lengthy, and even boring. I also detailed the translational barrier of applicability. My participants said that theories are not “actionable,” and that they tend to prefer clear, simple recommendations: “The whole idea [of using academic research] just seems like a waste of time when I can Google something, and then get tons of well written articles that are visual, fun to read and actionable” (Colusso et al. 2018 or Chapter 4).

I framed the problem as a mixture of understanding and applicability. First, the academic writing style undermines the practitioners’ interest in research. Theories are too complex, abstract, and uncertain, and practitioners do not know how to navigate publications to find what they need. Second, HCI practitioners think that theory is not applicable to their practical work; they do not know how a theoretical insight could be connected to the design process. These two barriers lead to HCI practitioners having little interest in HCI academics’ work, as the perceived benefits do not offset the cost to read lengthy, complicated research papers that are not actionable. Therefore, underlying the Translational Research problem in HCI are the incentives, or lack thereof, to engage in it. HCI practitioners have little incentive to read lengthy and time-consuming research papers, as they may not find actionable insights and may not even understand much of the text. On the other hand, academics’ incentives very often revolve around publishing scientific findings and advancing their careers in academia. The results of my dissertation suggest that applicability is the main barrier between HCI research and practice. There are other barriers at play such as access, collaboration, and culture, among others.

**Table 14. Main barriers that prevent designers from using academic research in the design process.**

Applicability	Understanding
Scientific writing does not seem “to the point” or “actionable” to practitioners, which undermines their interest and ability to use scientific results in the design process.	The jargon and structure of scientific publications undermine practitioners’ ability and interest in reading and understanding scientific writing.

Scientific results are presented in a format that does not lend itself to easy use in practice. Many academic resources do not take into account all the details and overgeneralize design situations that practitioners face. Specifically, theories focus on divergence instead of convergence—this is difficult for practitioners who deliver concrete solutions.

The academic writing style undermines practitioners' interest in research. Theories are nuanced and abstract. Some framings may even have negative connotations for practitioners. Also, academics do not like to have their work translated to a more practical language and context, as it often misses key nuances.

(Colusso et al. 2017; Colusso et al. 2019; Buie et al. 2013; Gray et al. 2014; Norman 2010; Norman 2010; Stolterman 2008; Barnard 1991, cited by Rogers 2004; Goodman et al. 2011; Schønheyder & Nordby, 2018; Roedl & Stolterman, 2013)

(Colusso et al. 2017; Colusso et al. 2019; Roedl & Stolterman 2013; Rogers 2004; Beck & Ekbia 2018; Buie et al. 2013; Gray et al., 2014)

### Artifact Contribution One: The Translational Science Model of HCI

Building on a deeper understanding of the gaps and barriers of Translational Research in HCI, I created the Translational Science Model in HCI (Figure 32), the main contribution of my dissertation. This contribution is a direct answer to RQ1—“What model for translation describes the translational gaps and activities across HCI?” To answer this question, I conducted a literature review, interviewed 43 diverse stakeholders in the HCI community, and iteratively designed the Translational Science Model. The starting point was searching for and analyzing models related to Translational Research in different disciplines, none of which seemed to represent the context within the HCI community. Within HCI, I continued the work of Gray et al. (2014) to uncover multiple relationships between research and practice.

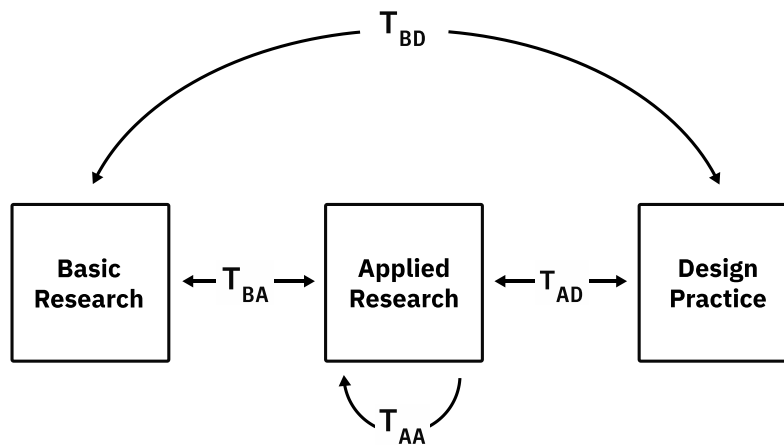


Figure 32. The Translational Science Model of HCI.

What functions does the model offer? In general, it allows the HCI community to better understand the space of Translational Research and how to engage with the full range of Translational Research

challenges, opportunities, and actors. Below I explain specific devices offered by the Translational Science Model.

First, the model visually articulates how Translational Research is not appropriately represented by the research-practice gap metaphor. Perhaps unsurprisingly, I found a multitude of gaps, groups, and translations across the HCI discipline that are obscured by the gap metaphor. More interestingly, the model introduces the very term “Translational Research” to HCI, which can expand the repertoire of academics interested in this space. The HCI community has not previously used “Translational Research” as a term to formally describe translational processes, it being a notorious term in the biomedical fields.

Second, the model establishes a nomenclature for this area of studies that can help the HCI community to see translational problem spaces differently. Specifically, the model reveals the multiple gaps in Translational Research in HCI that go beyond the subcommunities of HCI researchers and design practitioners. I found the indication of a gap between basic researchers and applied researchers in HCI and, interestingly, a gap that indicates fragmentation within the HCI community. The work of each of these groups—HCI academics, academics from other disciplines, HCI practitioners, and other translators such as industry researchers and science communicators—across each gap is an important part of Translational Science in HCI. Also drawing from the biomedical fields, I introduced the T-terminology to HCI. The T-terminology serves to more precisely denominate gaps and to position translational barriers in the space of Translational Research. Evidently, translational barriers had been previously framed by a view of a single gap between research and practice. In the Translational Science Model, I specify how barriers are allocated and are more active in specific gaps. This way, the model can help organizations target gaps and barriers where HCI knowledge is stalled and catalyze work that can facilitate translation.

For example, the Translational Science Model for HCI shows applicability to be the most significant barrier preventing HCI research from influencing design practice ( $T_{AD}$ ). To facilitate the translation of work stalled at this stage, the HCI community might focus on translations that make it easier for practitioners to apply HCI findings, whether that is ease of use or understanding how or what in theory is applicable. The important piece is centering HCI practitioners as users of academic scholarship. This would involve systematically asking questions such as “Is this privacy recommendation found in a CHI conference paper effective or used/adapted in different ways in practice?” and following up on those questions. This example shows how the model may be used by HCI academics doing Translational Research to describe and shape their work. With a more specific Translational Science model, the health field devised initiatives such as dedicated budgets, research centers, scientific journals, and conferences for different gaps (Woolf 2008). A specific plan that emerged in the health domain was to reduce cancer mortality by 2025, consisting of concentrating translational research in a few centers that can vet and test clusters of scientific findings with the most potential (Cheever et al. 2009).

Using this model to discuss Translational Research in HCI can help translational researchers and institutions in academia or elsewhere to more clearly define and target different translational gaps. A criticism of the Translational Science Model for HCI is that it can over-rationalize complex arrangements of knowledge, artifacts, and actors. However, although I worked to avoid such criticism by being as

inclusive as possible of diverse groups and practices, models by nature tend to streamline complexity.<sup>7</sup> In any case, I have been a strong advocate for other researchers to challenge and expand the model or propose other models and metaphors. Doing so can only benefit the discipline.

This contribution raises awareness of a greater range of barriers and opportunities, supporting HCI in problem-solving specific barriers more precisely and in ways that were not obvious when the research-practice gap metaphor was the dominant narrative about Translational Research in HCI. For example, I found applicability to be the most prominent barrier preventing applied research from informing design practice ( $T_{AD}$ ). Therefore, efforts to reframe the scientific lingo at this gap might not be as valuable as creating resources that designers can use to brainstorm, prototype, and build products. Conversely, for basic research to directly inform design practice ( $T_{BD}$ ), it is worth exploring strategies that reduce the “language” barrier to facilitate understanding between basic researchers and HCI practitioners if engaged in a conversation or they are trying to understand the informational needs of these HCI practitioners and reframing research findings accordingly.

**Artifact Contribution Three: Taxonomy of Informational Resources Driving Design Activities**

I also examined what makes informational resources useful to HCI practitioners. I asked RQ2: “What resources do HCI practitioners use to inform their work? How do HCI practitioners use these resources?” and described what resources HCI practitioners do use to inform their work and how they use these resources to inform specific design activities. These design activities are:

- a. building foundational knowledge of how to approach a design challenge
- b. generating ideas of possible directions to tackle a design challenge
- c. moving from a preliminary idea into product development with prototyping or detailed design
- d. using data to advocate for a design solution with other decision-makers

For each of these activities, practitioners valued direct and familiar terminology, abundant visual examples, and resources that can be easily and quickly applied into their daily work routines. See examples of resources and how they are used by HCI practitioners below. Resources highlighted with an asterisk in Table 15 were the most used by designers in our study.

**Table 15. Taxonomy of resources used by HCI practitioners to inform different design activities.**

<b>Activity</b>	<b>Resources That Support This Activity</b>
	Examples of Resources
<b>Understanding</b>	<b>Models</b>
Build foundational knowledge of	Contextual user research,* books, articles*

<sup>7</sup> This reflects a common Translational Science discussion about how often scholars write rich, nuanced findings, which may become intractable, difficult to understand and use. Simplifying theories might facilitate adoption, as it is more legible, but it inevitably reduces the nuance of a theoretical insight.

how to approach a design challenge	<b>Others' Experiences</b> Reputable case studies on Medium.com posts,* Nielsen Norman Group articles, recognized experts or similar others on Slack.com channels, Reddit, Reddit.com Ask Me Anything (AMA) sessions
<b>Brainstorming</b> Generate ideas of possible directions to tackle a design challenge	<b>Understanding Resources</b> User research data, resources generated by designers in Understanding
	<b>Design Examples</b> Dribbble.com,* Google Images,* Behance.com,* Pinterest.com,* Ideation cards, Science fiction books, Pop psychology books, Design books
<b>Building</b> Move from a preliminary idea into product development through prototyping or detailed design	<b>Libraries</b> UI libraries,* books, blog posts
	<b>Existing Apps</b> Apple's App Store, Google Play App store, ProductHunt.com
	<b>Forum-Based Websites</b> StackExchange.com, StackOverflow.com, Quora.com
<b>Advocating</b> Explaining design rationale	<b>Evidence For Idea Or Chosen Solution</b> User research, trusted resources, academic research

I estimate that the activities and resources in Table 16 can be generalized across different design processes. Regardless of the nature or the objective of a designer, they will attempt to understand their design space, ideate, and produce an outcome. A designer will also often advocate for their ideas or design outcome, and even if they are designing “solo,” there is likely to be a situation in which they will explain their design to another person.

It is also generative to connect the findings represented on the taxonomy above to the Translational Science Model proposed earlier. With the model, one can think about different ways in which informational resources coming from basic research and or applied research can inform design activities. For example, perhaps a translation of basic research findings on the impacts of disinformation on quality of life could be translated into a resource for advocacy, which could then be used by a product manager working for a social media organization to highlight the importance of stopping disinformation from being broadcasted in the platform. Note how different such knowledge translation is from a potential design feature for flagging disinformation or a process to identify disinformation investigated by applied research in HCI. In the later examples, the outcome could inform building or even brainstorming activities instead of advocacy. If an organization is at a stage of decision-making, discussing if a course of action should be a priority (or how much of a priority it should be), then different translational resources might be more or less appropriate for translating theory into change.

There is a key insight that we can draw from overlapping the Translational Science model with the Taxonomy. As I expanded the landscape of barriers and translations with the model, and the ways in which theory can inform design activities with the taxonomy, it is possible to observe many permutations that are fruitful for future Translational Research. For example, Bubble-Up is very likely to be different across the T's—how a basic researcher can learn from design practice is likely very different from how an applied researcher learns from design practice. This also has implications at the level of specific activities. If researchers engage in Bubble-Up, how do they do so? Which research activities are informed by practice knowledge and through which channels or resources?

These insights on translational barriers and how to support specific design activities directly informed the subsequent studies in my dissertation. If knowledge users can understand how knowledge is communicated (the barrier of understanding) and how it can be applied to problem-solving (the barrier of applicability), then part of the Translational Research space in HCI will be better served. The need to consider how these specific barriers affect knowledge exchanges in HCI shaped the scope of this dissertation, inspiring my efforts to investigate how HCI can facilitate Translational Research. I explored these two barriers in classroom-based engagements between students and literature coming from the behavioral sciences and HCI, engagements in which students made use of methods and tools that I created and evaluated for the purpose of this dissertation.

Most theories are not created to inform the work of HCI practitioners; and there is abundant published scientific research that might never be translated by experts into design resources. Therefore, I created and evaluated activities to read and understand theories and a method to apply theories toward the creation of prototypes.

### **Artifact Contribution Three: Active Reading Exercises for Understanding Theories**

To answer the question, “How to facilitate nonacademics’ reading and understanding of scientific research?” (RQ3), I designed and evaluated a learning module consisting of a reading guide activity and a card-creation activity. I contributed a set of opportunities for design educators seeking to teach HCI/UX students how to read, confidently navigate, and understand scientific publications.

Unsurprisingly, participants said that they were not previously taught how to read scientific writing and apply it to design work. Consider a traditional course that many college students take such as Psychology 101. This course is often a pre-requisite for design and HCI programs. Sure, college students may get guidance and exposure to scientific research, but when joining a design-oriented major, the connection between scientific research in Psychology and interaction design practices is not traced. In this scenario, the student learns two important bodies of knowledge that have definite connections and is left to make those connections on their own. This, of course, implies the scenario of an HCI practitioner that attended a university with design-oriented majors. In reality, many HCI practitioners may not even attend an accredited educational institution. Below, I discuss my findings related to understanding scientific readings and using the readings for problem-solving.

Participants thought that having a structured approach with tangible instructions for the readings was valuable, which supports the work of Tashman and Edwards (2011a) and Yore et al. (2003). An important aspect of the learning module is that it reached a good balance between the time needed to accomplish the activities and the level of guidance and scaffolding provided, where “balance” means that the reading did not feel easy or too simple but also not too time-consuming or overwhelming. I pointed participants to parts of publications and explained how they can serve specific functions, which helped readers to find definitions of theoretical concepts or takeaways for design. My results also support past work stating that simply paraphrasing content can raise awareness for understanding gaps and transforming ideas into familiar, more memorable ideas (McNamara et al. 2004). Other techniques might be able to achieve such balance. More work needs to be done to evaluate my learning module, as well to design and evaluate other techniques.

Other than reading, a deeper understanding of theory involves exploring how theory could or could not be used in problem-solving. I found that creating cards opened up a space for participants to critically engage in the intersection between theory and practice and to challenge, expand, and adapt theories—exactly the kind of critical thinking that we expect from students in the classroom (Yore et al. 2003). For example, participants could propose constructive ways for theories to inform practical design and research techniques. There is the obvious process of advancing abstract discussions about theory specificity into a practical level. A side benefit of card creation exercises is the generation of a set of resources that readers can revisit later. My participants built their own repository of notes and cards, which incentivized engagement and learning, and stated that if they ever had to refresh their memory about a theory, they could reference this catalog of learnings. This finding supports past work positing that when readers themselves organize, review, and trace their extracted content back to its source, it increases learning outcomes and may facilitate recall (Adler et al. 1998; Schilit et al. 1998; Tashman and Edwards 2011b). A challenging aspect of creating a theory card is finding interesting and relatable design examples to illustrate scientific findings. However, as participants noted, the search process challenged them to consider the applicability of theories, which was helpful. One potential solution that I have explored is to allow students to create their own original examples instead of solely relying on existing products, although this is yet another time-intensive activity. The instructors that I interviewed highlighted the value of cards for encouraging students to think about the breakdowns of theories. Asking questions encourages students to use their expertise to explain how a theory is not applicable or how theories could be extended instead of acquiescing if a student dismisses the relevance of a theory.

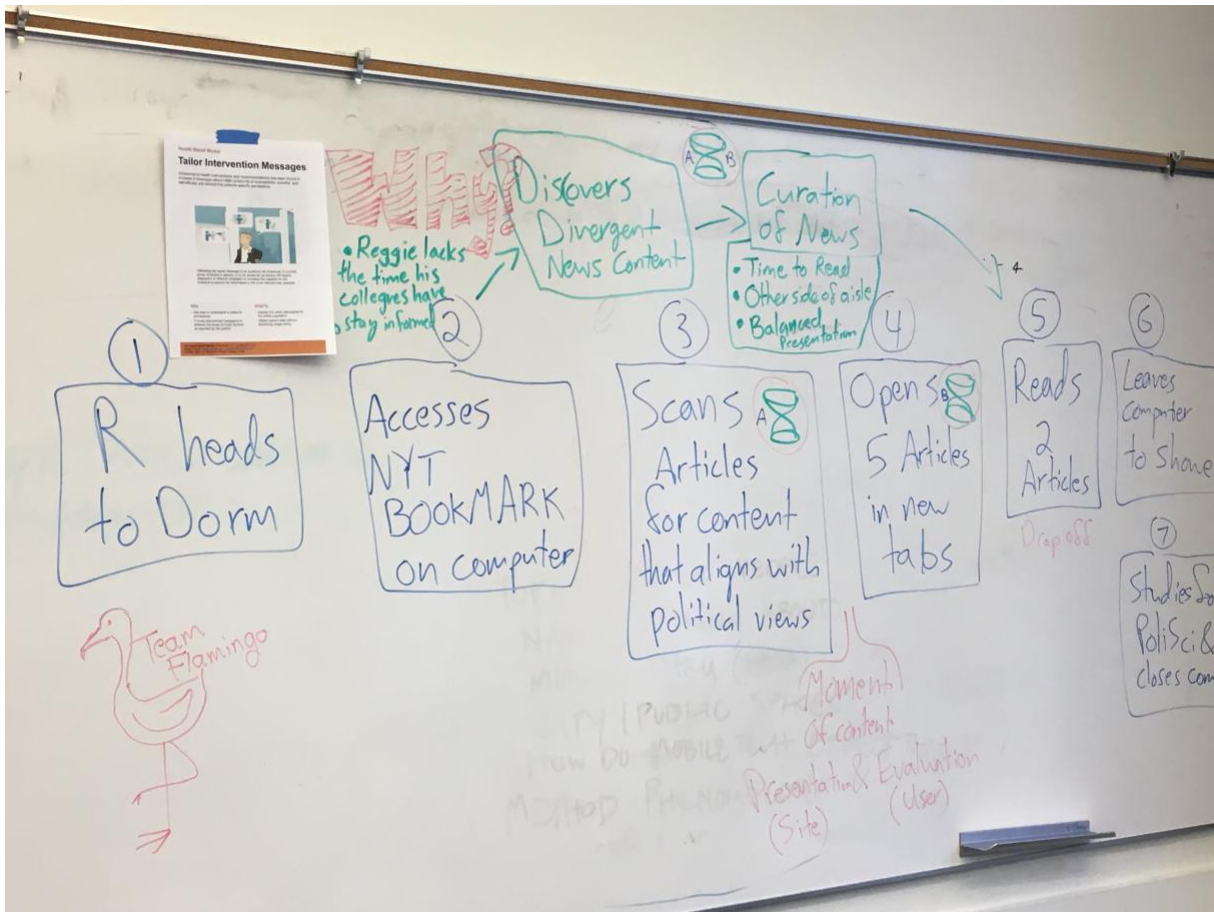
While I devised reading and card creation as individual exercises, I found that the theories and activities also supported group-level thinking and learning. Participants were very interested in practicing advocacy with the support of scientific findings, saying that presentation skills are critical in HCI practice and that theories give them more confidence to make arguments. Kreitzberg et al. (2019), Bybee (1995), and Hand et al. (2001) discussed how professionals must acquire skills to inform and persuade others—and organizations—to take action. I first emphasized self-explanation in the exercises and then expanded the exercises to include the practice of peer-explanation. Self-explanations seem important as a pilot to articulate knowledge and correct misunderstandings of theoretical concepts individually before students

have to expose their emerging knowledge to others. Articulating knowledge at this early stage involves interweaving paraphrased theoretical concepts and annotations with additional thoughts based on students' experience, which is crucial for learning (McNamara et al. 2004; Osborne et al. 1983). A drawback of self-explanation is that if students stop there, they may be stuck with misunderstandings or gaps in understanding. Peer explanations and discussions not only expand readers' capability to identify misinterpreted information from the source text, but also help students to collaboratively make sense of the readings. Having diverse backgrounds in the classroom and pairing diverse students is important to encourage the consideration of different ways to interpret theories as well as of the many instances in which theories can be useful. For instance, in the class I observed interesting discussions between engineers, designers, and psychologists about using theories in real problem-solving scenarios. Such findings build on past work and can draw interesting connections with other teaching strategies such as Think-Pair-Share, which may improve critical thinking, textual analysis, and argumentation (Kaddoura 2013). In a different context, such findings can inform the formalization of reading groups, often times held in non-structured environments such as "brown bag lunches."

Providing appropriate feedback in reading and translation exercises remains a challenge, as it requires extensive review and poses a heavy burden on instructors. Evaluating evolving theoretical knowledge or translated theory as right or wrong is perhaps impossible. It is important to create a culture where those involved in translations feel comfortable engaging with science without the pressure to know everything or get things right all the time. A more valuable evaluation might assess understanding (e.g., misunderstandings that lead to wrong conclusions and new or rich understandings about practice and theory). More investigations are needed for ways to evaluate and provide productive feedback for translational research activities in the context of classrooms and translational projects.

#### **Artifact Contribution Four: Sprints for Prototyping Theory-Informed Designs**

Moving past the barrier of understanding, I probed into the question, "How to facilitate the use of scientific findings in the design process?" (RQ4) by creating a design method called Behavior Change Design Sprint (BCDS). I found that in order to solve problems with a theory-driven approach, practitioners need an easy-to-follow framework that does not conflict with their existing process. Below, I explain the benefits of different exercises that form BCDS.



**Figure 33. User journey example that I provided students as guidance.**

The *Journey* exercise (Figure 33) facilitated visualizing and tackling translational problem scenarios. Specifically, the exercise helped groups to identify how to deliver theory-driven design interventions. Past work has described “time” and “place” as critical aspects in designing effective design interventions (Adams et al. 2015; Hassenzahl et al. 2014). Participants said that leveraging theories helped them make more certain and confident decisions on which ideas to invest time in and, ultimately, to prototype and test. Group discussions used the journey to promote agreement and convergence, which are commonly lacking in brainstorming sessions (Cooper et al. 2014). This can potentially lower the cost for groups of designers and researchers to tackle translational problems. In addition, the journey helped students and professionals to think about the measurement of interventions. Considering the effectiveness of behavioral interventions from the outset instead of focusing on their aesthetic or ease-of-use is an interesting addition to the design process in service of Translational Research in this space.

Theory cards seem to encourage HCI practitioners to brainstorm design ideas that align with theory, which can be an interesting addition to the more divergent thinking encouraged by standard ideation techniques such as brainstorming. I found that cards with clear examples of theory instantiations in current products as well as stories of products that may have been influenced by academic research can

support designers. Even if academics are not completely confident of the links between a specific academic research and a product or a service, applied and current examples are still a powerful way to communicate concepts that designers can understand and apply to their context. However, there is a perhaps unavoidable disconnect between what academic research offers (general theories, implications, and recommendations) and what a designer is expected to produce (a tangible design).

Participants said that theories were helpful in supporting advocacy, an important skill for HCI practitioners. Participants mentioned being more confident explaining their design rationale using scientific findings, which supports results from Chapter 4 and Chapter 5. This reveals an interesting consideration about the applicability barrier. The use of scientific findings by HCI practitioners may not only help to design something tangible, but also may be used to influence discussions and decisions. Such findings support Weiss's (1995) work exploring the history of social science knowledge use in America. Weiss specifically studied how science informs the work of government officials, finding that decision-makers believed that their ideas were influenced by science, although they could not cite the name of any particular study or even remember reading a research report. Officials talked about scientific findings at meetings, conferences, and in lunchtime conversations. In light of these engagements with government officials, Weiss argued that "research use" can have different meanings apart from what social scientists assumed it meant: using research to shift from Policy A to Policy B. Government officials used science for enlightenment to increase understanding of a policy terrain, warning of conditions that are beyond the zone of acceptability, guidance for actions (which is rare), and argument legitimation (similar to our findings with HCI practitioners in Chapter 4—understanding, brainstorming, building, and advocacy). There might be other ways to facilitate the use of scientific findings in the design process and among different audiences. I further discuss these opportunities in the next session.

Finally, BCDS seemed to help participants to apply theoretical concepts into design without needing to engage with the research producer or conducting their own research. The speed with which participants were able to output behavioral change prototypes raised ethical questions, as our attempts at encouraging ethics discussions were not sufficient. Weiss also highlighted potential drawbacks of such an approach:

People in Washington have enough experience now to realize that there is probably another study that reaches different conclusions, maybe even contradictory ones. If they shop around, they can probably find a study to support almost any stand they want to take.  
(Weiss 1995)

Nevertheless, educating audiences to become responsible translators of theory is crucial, and there are opportunities to more strongly raise awareness and discussions about ethics throughout the entire sprint instead of in a distinct step at the end of the sprint.

Finally, making and evaluating the artifact contributions described above raises an important point. As I actively engaged with the space, I had an opportunity to closely understand and generate Translational Research in HCI. Underlying the work in this dissertation is a pragmatist perspective of how interpretations of the world, whether they are ideas, theories, and assumptions, can be assessed in light of

the consequences and influence they have in practice. My work suggests that theories do not exist in a separate and abstract world and that their value can be partly defined by how they can be tools for practice, in which case the criteria proposed by Sas et al. (2014) should be formally implemented in the field and possibly expanded. Doing so may influence the work of other HCI researchers interested in the pragmatic view that the socioeconomical value of HCI research increases when it is understood and used by responsible HCI practitioners.

## **Future Work**

There are many Translational Research topics and opportunities that the HCI community can explore. In selecting the following items, I considered what areas need focus, based on my findings and growing understanding of Translational Research. Opportunities to support knowledge translation and use as well as understanding bidirectional and goal-oriented knowledge exchanges in HCI abound. Presumably there should be infrastructure in place to lead and monitor such efforts. Therefore, for closure, I provide insights for how to use existing infrastructure or to enhance infrastructure to solidify and monitor Translational Research.

### *Supporting Knowledge Translation and Use*

The Translational Science model shows that knowledge will not travel across HCI and related fields without translation work. I discussed how tools such as step-by-step guides cards, and scenarios can support knowledge translation and use. It is important to keep iterating on the tools and exploring the uses of many other types of tools, problem-solving for specific barriers and the needs of different knowledge users.

First, within the scope of informing HCI practice, there is an opportunity to further study how to influence different design activities. Currently, it seems that design implications generally produced and published in HCI publications struggle to situate research findings in the context of HCI practice. There is interesting work to be done around mapping how different kinds of research findings can influence different design activities. The design activities that I found in my work (understanding, brainstorming, building, and advocacy) are a good place to start, but how should we map research findings into these activities formally craft findings as successful translational resources demand much more investigation? Currently, the use of design cards is pervasive. I have used such artifacts extensively in my studies, however, other artifacts with recommendations for different activities might be useful. For example, ethnographies may not provide specific design implications for building or advocacy but can help practitioners to understand more about design context (Dourish 2006). Models or vignettes drawn from ethnographies could be adapted into personas and scenarios and used as input materials in BCDS or other methods, but more work needs to be done to understand how these theory-driven resources can be produced and also help designers to apply theories in their work. Also, again, as academics are often not incentivized to create translational resources, partnering with designers, visual artists, educators, and writers to create these resources is a potential avenue to explore.

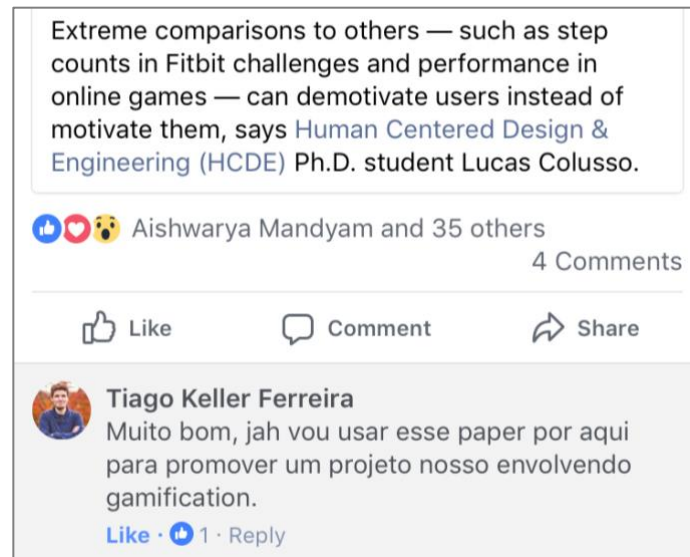
Second, many opportunities remain to support knowledge translation and use beyond HCI practice. Most of the participants of studies in my dissertation were HCI practitioners, but as seen in the Translational Science Model, translations in HCI go beyond the gaps informing HCI practice. As most participants were HCI students, they probably approached the translational resources with a mindset that differs in some ways from that of practitioners, though at this point it is unclear how. It is also important to investigate different areas of the Translational Science Model and to potentially expand its current areas of focus, which is an exciting venue for exploration. Possible venues include: investigating how basic research engages HCI practice, how HCI researchers communicate and collaborate with each other, or how they engage with science communicators and with policymakers. This highlights the consideration of what applicability means for Translational Research, when the use of scientific findings not only helps to design things, but when it is used to influence discussions and decisions, as examined on the previous page in relation to Weiss's work (2005). This can be achieved by studying expert translational researchers in different fields. Who are successful translators? How did they navigate successful and failed translations in the past? And what other practitioners apart from HCI practitioners can take part in the Translational Research endeavors involving HCI?

### *Understanding Bidirectional and Goal-Oriented Translational Research*

As the view that knowledge originates from a centralized legitimizing source and then diffuses to knowledge users becomes obsolete, it is key to further understand the reciprocal connections between research and practice in HCI. This concept of engagement can make translations more relevant and effective and also build the perception that associated groups are interested in each other's work, will listen to each other, and will be able to provide useful information. These relationships can become channels for successful knowledge translation over time if enough consideration is spent on understanding such relationships as well as their common goals.

First, it is important to more deeply engage with translational science stakeholders. While my work focuses on the academic-HCI practitioner relationship, the Translational Science model shows potential for building the capacity to collaborate and coordinate with many other stakeholders beyond HCI practitioners, blending scientists, engineers, science communicators, activists, and end-users to produce new research and translations, supporting Shneiderman (2016). More understanding is needed about how these diverse parties engage—and how they could engage—in Translational Research. For instance, I found in my work that the translations between basic research and applied HCI research are understudied and represent an exciting area for future work. Also, industrial research labs may directly hire basic science researchers who presumably engage in translation work as part of daily routines (Chapter 3). This also speaks to how HCI contributes back to the original bodies of knowledge or design it investigates and from which it draws. In addition, an effective knowledge feedback loop can help keep the HCI field grounded in and relevant for HCI practice. Further work can investigate how to engage practitioners as partners in the process to produce ideas for research and other research activities. But an important discussion to be had concerns when academia needs to offer counterpoints to what industry and practitioners want and how to go about offering counterpoints. It would also involve investigating

channels that HCI practitioners already use to publish and discuss their issues (e.g., Reddit communities and Medium publications, each with hundreds of thousands of users) (Kou and Gray 2018). For example, Tiago Ferreira wrote on Facebook, “*Very good, I will use this paper here to promote a project involving gamification.*” At the time, Tiago was a software engineer at an educational gaming company and used the findings to inform feature brainstorming for a new game (see Figure 35). Work for the purpose of understanding bidirectionality in Translational Research for HCI can draw from my dissertation and the work presented in Gray et al. (2014).



**Figure 34. Message that the author received from a connection in a social media platform.**

Second, it is also important to open up and expand the units of study of Translational Research, moving beyond individuals or small teams. Greenhalgh et al. (2004) advocate for Translational Research groups prioritizing and studying research questions across multiple programs in a variety of contexts, rather than small isolated groups ‘doing their own thing.’ In this way, the impact of place, setting, and context can be systematically studied. As mentioned before, a persistent self-criticism of the kind of Translational Research in HCI that I conducted rests on the fact that individual adopters (in my studies, a sliver of HCI practitioners and students) have been the only units of study. There is a remarkable diversity of adopter units, varying from the individual to the small group, large organizations, or governments. In translational medicine and education, for example, the primary unit of analysis has typically been not individual practitioners but the systems they are embedded in—school systems, public health programs, community centers, or hospitals. Future work in HCI could compare patterns of knowledge translation and relationships across organization sizes as well as inter-organization relationships (e.g., a university and a local startup or larger organization). Doing so could give insight into relative advantage to indicate the return of investment of resources and other factors such as proximity, structure, and frequency of communication. Such studies could be of enormous value, supporting an understanding of when findings from one organization or group might be applied, at least tentatively, to other settings. The HCI field

could even consider ways for organizations to assess how they are doing regarding translational research. For example, a company could use surveys and other indicators to understand whether the resources they spend on paying for their employees to attend academic conferences translate into improved services and products.

A potential implication of more efficient Translational Research is that translational efforts might benefit those who are most competent already and hence are least in need. Researchers should strive to avoid this rich-get-richer effect. They should serve locales with multiple capacities, or even focus on organizations that do not have the resources to conduct applied research, and this service can be thought of as an opportunity for HCI to maximize impact by informing or engaging with smaller companies or startups, activism sites, small universities, and communication and tech transfer groups. In sum, expanding the units of study could help expand the impact of HCI knowledge in multiple fields and our understanding of Translational Research in HCI simultaneously.

Of note is that Translational Research also does not account for critical events such as governments' shifting policies (which were a major factor in the growth of Translational Medicine in the early 21st century as seen in Chapter 2), crises, and public opinion shifts, which play important roles in knowledge dissemination and use. These catalytic events and the moving forces for societal change can only be understood in a broadly social, historical, and political context. For example, as I write this dissertation in 2020, the COVID-19 pandemic has driven the rapid adoption of contact tracing technology in some regions, driven the public to learn quickly about the associated privacy risks of such technologies, and also driven organizations and workers to rapidly adopt distance learning and remote work technology. A truly comprehensive model of Translational Research would need to account for these events and spell out how they influence translations.

It also seems that countering the dominant linear models of knowledge dissemination and translation will require more work, as will understanding and articulating shared goals for groups involved in Translational Research. In Translational Medicine for example, one may assume that the goal is to translate knowledge resulting from basic science into ideas and knowledge about bodies and medical technologies, which will then be implemented in clinical practice, resulting in healthier individuals and improved public health. However, the goal of all steps is to simply improve public health, saving and improving lives (Van der Laan and Boenink 2015). Linear models have definite advantages because they order steps on a timescale and suggest a division of labor, thus indicating a logical flow of knowledge. But the perceived advantage of linear models has been shown to be a flaw by Stokes (1997) and Shneiderman (2016), who argue that the supposedly temporal, linear relationship between basic and applied science and practice is inefficient. For these authors, this is in fact where the danger seems to lie; the division of labor dilutes the overall goal, allowing groups to emphasize and target their inner goals and culture. For example, these authors claim that impactful scientific research should always be driven by the end goal, and Stokes cites the famous work by Pasteur which substantially contributed to both fundamental understandings in microbiology and advances in the treatment of bacterial infections. Several studies also show that the division of labor and the timing suggested by the linear model may actually block successful innovation in industry. A lack of attention for research, implementation,

regulatory, or ethical issues during multiple phases of innovation may cause failures in implementation or a lack of acceptance (Luo 2015).

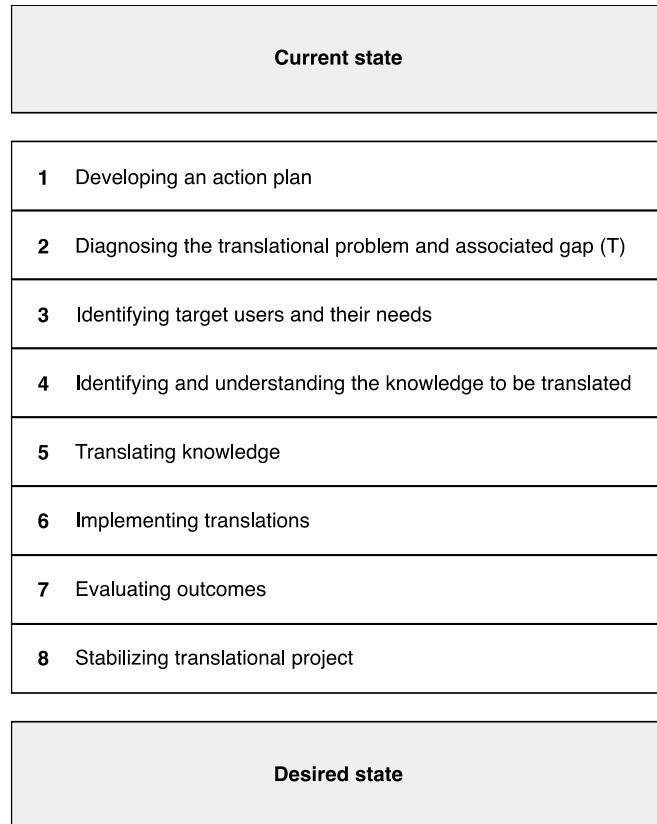
This raises the question of what the desired, ultimate outcome is for translational research in HCI. Perhaps the HCI field could pay more attention to establishing clear end goals that can be contested, altered, and expanded. A field can also have multiple goals but clarifying these goals and developing ways to measure progress towards goals is important. What is the equivalent of saving lives and making people healthier for HCI? This is a very interesting point to consider in future work. ACM SIGCHI (Special Interest Group on Computer-Human Interaction) articulates its mission as the following:

ACM SIGCHI facilitates an environment where its members can invent and develop novel technologies and tools, explore how technology impacts people's lives, inform public policy, and design new interaction techniques and interfaces. (ACM SIGCHI Mission Statement n.d.)

The Constitution of the World Health Organization (WHO 2014) defines health as “A state of complete physical, mental, and social well-being, not merely the absence of disease.” The WHO stated that the measurement of health and the effects of healthcare must include both an indication of changes in the frequency and severity of diseases and an estimation of wellbeing. Wellbeing in general can be assessed by measuring the improvement in the perceived quality of life related to healthcare in relation to people's goals, expectations, standards, and concerns (WHO 2014).

If I were to articulate the goal of Translational Science in HCI, I would heavily lean on ACM's current mission statement.

Finally, based on my experience in Translational Research and scientific findings yielded during the course of my studies, I created a draft for a Translational Research process in HCI (Figure 35, next page). The guide, which is yet to be evaluated in future work, provides a user-centered framework for all interested in Translational Research in our community to think about what can appear to be a nebulous charge. The guide would encourage translational groups to think through the process and to assemble the building blocks needed to construct a formal Translational Research plan specific to their project and their intended users' needs. As a living, collaborative document, the plan helps with alignment and can be changed as additional information emerges. While an individual such as the principal investigator may coordinate completing the plan, they would be dedicated to fully capitalize on the interdisciplinary group's knowledge and to gain their support of the plan. Optimally, the planning group should include end users (of the translated knowledge) and all partners to better understand their needs and the best possible methods for translating knowledge.



**Figure 35. Quick-Start Guide for Translational Research in Human-Computer Interaction**

Finally, by choosing a problem-solving, human-centered perspective for translation stresses the central role of the ultimate user of a knowledge translation. As this perspective is traditionally instigated by a need within the user, the proposed eight parts of the guide could lead a translation group through steps to satisfy user needs, striving to change the current state of affairs to a desired state of affairs (Figure 35).

### *Developing Infrastructure and Drawing on Existing Infrastructure*

Finally, I hope that more HCI departments, laboratories, as well as research grants will be directed toward Translational Research. HCI can build more translational capacity by either funding more Translational Research infrastructure or leveraging existing infrastructure.

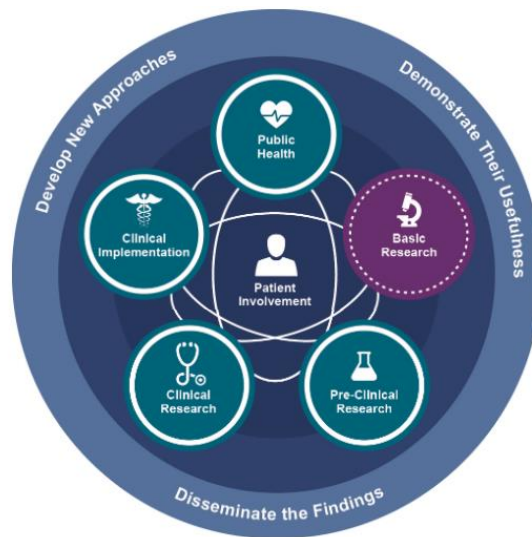
Building capacity for Translational Research in HCI might entail gaining traction by allocating specific resources to attract students, researchers, and professionals. Dedicating specific resources for Translational Research at large or for discrete steps of the translational spectrum has been a hallmark of Translational Medicine. The National Institutes of Health (NIH) in the United States of America, for example, has historically funded more basic research than health services research or clinical research (Packalen and Bhattacharya 2020). Packalen and Bhattacharya have found that the NIH funding has become more conservative throughout the years, focusing on funding applications of well-established, older (at least seven years old) research findings. Woolf (2008) also explained that the focus has always been on basic research and T1. Arguably, the federal responsibility for T2 research lies not with the NIH

but with the Agency for Healthcare Research and Quality (AHRQ). But Congress in 2020 allocated AHRQ only approximately \$444 million dollars for such work, about 1% of the NIH budget (Table 16).

**Table 16. United States of America science programs budgets (Mervis 2020)**

<b>Agency</b>	<b>2020 budget (\$ billions)</b>
NIH	41.68
NSF	8.28
NASA Science	7.14
DOE Office of Science	7
NOAA	5.35
USGS	1.27
USDA-AFRI	0.43

However, the NIH also established the National Center for Advancing Translational Sciences (NCATS) in 2012, the mission of NCATS being to transform the translation of scientific discoveries so that new treatments and cures for disease can be delivered to patients faster. The budget provided to NCATS for fiscal year 2020 was \$832,888,000 (NCATS Budget 2020) to move research across the spectrum. See the diagram below for all NCATS areas of operation.



**Figure 36. NCATS Translational Science Spectrum (NCATS 2020)**

The numbers listed above in Table 17 show how Translational Medicine has worked to allocate specific funds for translations, even directing and creating centers to focus on them. Based on Table 17, one can immediately notice the discrepancy in the sheer amount of resources available when comparing the NIH and NSF budgets. I highlight this comparison, as both the NIH and the NSF have historically been funders of HCI research either directly or indirectly. For example, it is common for HCI researchers

to collaborate and get funding via projects based on medical research departments. A more precise allocation of resources for different T's could benefit the HCI community, making sure that HCI knowledge travels across the translational continuum. How to engender such change is an open question. More work needs to be done to understand the funding structures and how to influence them in order to expand Translational Research in HCI.

It is also important to consider how existing infrastructure could be leveraged for Translational Research, which could open up the view of what it takes to do and study translations. This may come at a relatively low investment, which can be done at the laboratory, research center, or departmental levels. For example, HCI researchers and practitioners organize and participate in a multitude of courses, conferences, weekend laboratories, seminars, workshops, trainings, and other limited-duration events. In these sites, groups of capable scholars, practitioners, and students read and discuss papers and designs and produce research and design. The notion that such events can be designed and studied for Translational Research purposes is still not fully appreciated. In the future, the Human-Centered Design and Engineering program at the University of Washington and its peer programs might want to revisit curriculum or classroom activities to make use of resources designed for this dissertation body of work. The continuous use and iteration of these resources as well as the creation of new resources is key and can drive other academic programs, companies, and individuals to discover ways to engage with and learn from theory, as well as to contribute to it.

It would also be important to question and explore how the HCI community can serve translational researchers from other disciplines, basic scientists and medical researchers for example. As I write this document in 2020, it is impossible to overlook the fact that the distributed, collaborative, and time-sensitive work of biomedical researchers creating and trialing potential vaccines for COVID-19 would be a ripe scenario for examining and improving Translational Research in an interdisciplinary fashion.

The HCI community could also introduce conferences or conference tracks, journals, or other channels devoted to Translational Research topics. In my search for HCI literature related to Translational Research I found modest material scattered across conferences, journals, or in gray literature available online in different platforms. Translational researchers in medicine observed that academic venues seldom spared space for translational research. To peer review and publish Translational Work, Marincola (2013) argued that it is crucial to recruit experts in both the clinical and basic aspects of science, arguing the importance of both the intricacies of molecular or cell biology, and the reality of dealing with sick individuals and their families, as opposed to laboratory testing animals. The first edition of the journal *Translational Medicine* was published in 2013. In the editorial, Marincola (2013) explained that the main goal of the journal was contributing to the advancement of clinical care through collaboration between scientists and clinicians. According to Marincola, this goal could help both basic and clinical scientists to “fill the gap” between them and focus on the “endgame”: the effective treatment of diseases affecting people as the scientific process in Medicine is meant, above all, to alleviate human misery. Marincola asserted that achieving the endgame is facilitated by connecting basic scientists with the reality of human disease. Van der Laan and Boenink (2015) agreed with Marincola and added that basic scientists easily lose sight of what is necessary to make knowledge or applications valuable for society. Marincola stated

that scientists investigating new potential therapies based on scientific breakthroughs are not inclined to learn why their findings do not work as well in humans as they did in the pre-clinical settings. Such discussion again comes back to the challenging question of what HCI's endgame is, if there is any, or if there are many endgames or goals.

For Marincola, in Medicine, such issues might be due to the fact that there is little room in prestige journals for negative results (pre-clinical models have shown a discouraging propensity to fail when applied to humans). Prestigious journals appear more fascinated with cutting-edge research of ever-growing complexity more than the humble reality of human disease. In addition, the difficulty in publishing negative results is compounded by the fact that often clinical research data are not as precise as laboratory settings enable in pre-clinical trials. Further, research that produces clinically relevant knowledge such as clinical trials and observational research receive insufficient attention and funding (Woolf 2008; Rubio et al. 2010; Van der Laan and Boenink 2015). Of course, conferences and journals, for example, are costly, and so such recommendation for future work is connected to the first recommendation related to funding.

### **Final principles for infrastructure**

1. We ought to build structures for facilitating communication with one another and with our colleagues in other disciplines. In order to have an impact we are going to have to organize, plan and coordinate our efforts in a more coherent way than we have done in the past. Most of all we ought to be structuring our activities so that they will evolve into policies and services that improve society.
2. We also ought to be open to one another, willing to change our own ideas about the process from listening to colleagues in research and practice. Above all, we should be open the public, sensitive to their needs and appreciative of their goals and values.
3. We ought to be building the capacity for research and development in this area by allocating resources, attracting graduate students, and making Translational Research a central activity in Human-Computer Interaction departments.
4. Finally, we ought to be aware of the rewards that are in store for us if we can succeed in this effort to make a science of Translational Research in HCI. This is a challenging and exciting field; if we can learn how to bridge the gaps between research and practice, and if we can effectively build bridges, we will surely unlock many avenues for societal progress.

## **Conclusion and Contribution**

In this dissertation, I have sought to contribute to the HCI community with understanding and tools to support Translational Research. I did this by examining the relationships between research and practice, academia and industry, and other groups that coexist across the HCI community. I identified gaps, translational barriers, and opportunities for HCI knowledge to travel and inform the work of HCI community members. I then designed and evaluated tools that integrate novel approaches to overcome specific translational barriers.

This dissertation research advances knowledge of Translational Research in the context of HCI. In Chapter 3 and 4, I examined the three questions: a) what model might represent Translational Research efforts in HCI? b) what resources do designers use to inform their work? and c) how do designers use these resources? Through qualitative studies with diverse members of the HCI community, I described needs, opportunities, and existing channels for Translational Research in HCI. I also detailed translational barriers for the circulation of HCI knowledge across different groups as well as many gaps and the work of a diverse set of groups aiming to precisely reallocate translational barriers. The main contribution of this first part of my dissertation is a model of Translational Science for HCI describing multiple gaps and channels for the circulation of knowledge. The model gives translational researchers and institutions, both in academia and elsewhere, clear purposes and insights for channels to use for translations as well as an in-depth consideration of translational barriers and associated groups with their own needs, goals, and incentives. Researchers and institutions can also more clearly define and target different gaps, translational barriers, or groups across the translational continuum. Additionally, I have provided design recommendations to create new translational resources that facilitate the adoption of academic scholarship in the context of specific interaction and user experience design activities.

My dissertation also contributes two novel translational tools. I designed and evaluated tools to problem-solve for two key translational barriers for the use of academic scholarship in design practice.

In Chapter 5, the learning module I created contains exercises aimed at facilitating the efforts of designers to read and understand theory. The learning module entails an active reading guide and a card creation generative exercise that help designers to navigate and make sense of dense scientific publications. I designed and evaluated such exercises to examine the question of what activities can help

nonacademics to effectively read and understand scientific research, and I demonstrated how these exercises supported the engagement of two cohorts of graduate students in Human Centered Design and Engineering with scientific publications. Through this classroom exploration, I showed the opportunities and challenges for HCI educators seeking to teach students how to read and understand scientific literature as well as professionals intending to independently understand theories. I mostly supported past work furthering how a structured and balanced set of prompts can greatly improve the experience of reading science, but in the context of design. Further, generating theory-driven design resources helped the readers to critically engage with the readings and to produce resources for further reference. I also detailed how to turn such a learning experience from an individual to a group experience, which can be helpful in the context of Translational Research tackled in group settings. Finally, I described challenges related to evaluating the correctness or quality of theory understandings and theory-driven design resources.

My dissertation research then examined the question of how to facilitate the use of scientific findings in the design process. I presented a novel method called Behavior Change Design Sprints, a rapid method for designers to apply theories into the design process without needing to engage with the research-producer or conducting research. In Chapter 6, I described the process to create and evaluate BCDS and the experiences of sprint participants. I found that using BCDS for problem-solving supported the creation of theory-informed prototypes. The use of journey exercises seems particularly promising, as they facilitate discussion and agreement within diverse groups and focus discussions on specific outcomes as well as ways to deliver interventions. This could decrease the cost of ideating Translational Research interventions in interdisciplinary teams. To further the findings from Chapters 3, 4, and 5, I found more details of which types of theory examples, coupled with design examples, can successfully inform the work of designers in generating ideas for prototypes and advocating for their ideas. Researchers in HCI and in other disciplines should continue to examine how design tools and methods can support Translational Research. Finally, based on my experience with Translational Research in HCI, I provide recommendations and a step-by-step for teams to engage with translational projects with a quick start guide.

In closing, my dissertation research provided an important contribution that can help establish a nascent Translational Science of HCI. The results of this dissertation expand existing Translational Research knowledge in HCI, providing detailed insights about the knowledge needs and goals of different groups—how they engage with knowledge translation, the barriers to do so, and so on. They also offer practical tools to support Translational Research efforts. While this dissertation research focuses on Translational Research in HCI, other fields of knowledge beyond HCI can benefit from my findings and proposed tools for improving their engagement with research and practice.

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# Appendix

**Translational Science Model participant information.** Self-reported information. I edited job titles to facilitate comparison and to protect participants' confidentiality. I rounded years in the HCI field for the same reason.

ID	Current job title	Areas of experience										Years in HCI
		Applied HCI research	Basic HCI research	Basic research	Teaching HCI	HCI Practice	Entrepreneurship	Media outreach	Policy	Activism	UX Research	
P1	HCI researcher and professor	•			•	•	•	•	•			13
P2	Design educator				•							28
P3	Entrepreneur	•				•	•	•				21
P4	HCI researcher and professor	•	•				•					13
P5	HCI researcher and activist	•				•				•		9
P6	UX researcher			•							•	2
P7	HCI researcher and educator	•	•		•		•					18
P8	Design researcher, educator	•			•	•	•			•		22
P9	Design researcher, professor	•			•	•						17
P10	Design researcher, educator	•			•							12
P11	Entrepreneur, designer		•			•	•					12
P12	UX researcher, educator					•					•	15
P13	Design researcher, educator	•			•	•						26
P14	HCI researcher and professor	•			•							14
P15	Design professor and educator	•			•		•					20
P16	UX researcher	•									•	10
P17	Chemistry researcher		•	•		•		•				2
P18	Academia relationship manager	•				•	•				•	39
P19	HCI researcher and professor	•			•	•						47
P20	UX researcher/manager					•					•	25
P21	UX researcher/manager					•					•	21
P22	Technology and Design writer							•				6
P23	Communication manager							•				5

P24	Basic researcher and professor		•	•								2
P25	Text and Visual storyteller							•				0
P26	Tech and policy professor				•				•			19
P27	Researcher and professor	•			•							9
P28	Researcher and professor	•		•	•							15
P29	UX designer					•						3
P30	Researcher and professor	•	•		•							29
P31	Developer					•						6
P32	Professor/researcher	•			•							18
P33	Basic researcher, professor		•	•								1
P34	User Researcher, educator				•		•				•	15
P35	Product Designer					•						10
P36	Interaction Designer					•						5
P37	Interaction Designer					•					•	9
P38	UX Designer					•						4
P39	Product Designer					•						15
P40	Industry Researcher		•	•		•					•	18
P41	Designer and Researcher					•					•	12
P42	UX researcher					•					•	8
P43	Basic Researcher		•	•	•				•			5

**Translational Resources study.** Participants' self-reported information.

**Practitioners in our sample. Self-reported job titles, industries, and experience. Above the double-line, participants from the interview phase; below, member check participants.**

P1	UX Designer	Consumer Electronics	5
P2	UX Designer	Agency	4
P3	Interaction Designer	Agency	3
P4	Visual Designer	Agency	4
P5	Visual Designer	Freelancer (Entertainment)	20
P6	Lead UX Designer	Retail	7
P7	UX Designer	Agency	5
P8	Technologist	Consumer Electronics	4
P9	Interaction Designer	Search Engine	3
P10	Game Designer	Virtual Reality	8
P11	UX/UI Designer	Agency	3
P12	UX Design Director	Finance	5
P13	Technologist	Games	4
P14	Senior UX Designer	Energy	2
P15	UX Researcher	Business Analytics	9
P16	UX Designer	Marketing	9
P17	Senior UX Designer	Health	8
P18	UX Designer	Education	1
M19	Product Designer	Advertising	7
M20	Product Designer	Virtual Reality	5
M21	Design Manager	Social Networking	14
M22	User Researcher	Videos	3

**Behavior Change Design Sprints study.** Participants' self-reported information.

<b>Participants</b>	<b>Design</b>	<b>Behavior Change theory</b>
<b>High school</b>	little to no experience	no experience
<b>7 total</b>		
<b>Masters</b>	3 advanced	7 no experience
<b>(P, S)</b>	6	6 novice
<b>18 total</b>	intermediates	4 intermediate
	5 novices	1 advanced

	4 no experience	
<b>Tech (T)</b>	Avg. 9 years	1 novice
<b>3 total</b>	of experience	1 intermediate 1 advanced

## 1. A) List of Publications

List of publications that I asked students to read. Most are theory summaries; the 4th and 8th publications on the list are empirical studies.

- The Transtheoretical Model or Stages of Change  
James O. Prochaska, Colleen A. Redding, and Kerry E. Evers. 2015. The transtheoretical model and stages of change. *Health behavior: Theory, research, and practice*, 125-148.

- The Health Belief Model

Victoria L. Champion and Celette S. Skinner. 2008. The health belief model. *Health behavior and health education: Theory, research, and practice*, 4, 45-65.

- The Theory of Planned Behavior

Icek Ajzen. 1991. The theory of planned behavior. *Organizational behavior and human decision processes*, 50(2), 179-211.

- The Theory of Planned Behavior

Larry E. Davis, Icek Ajzen, Jeanne Saunders, and Trina Williams. 2002. The decision of African American students to complete high school: An application of the theory of planned behavior. *Journal of Educational Psychology*, 94(4), 810.

- Social Cognitive Theory

Aleksandra Luszczynska, and Ralf Schwarzer. 2005. Social cognitive theory. *Predicting health behaviour*, 2, 127-169.

- Goal-Setting Theory

Edwin A. Locke and Gary P. Latham. 2002. Building a practically useful theory of goal setting and task motivation: A 35-year odyssey. *American psychologist*, 57(9), 705.

- Self-Determination Theory

Richard M. Ryan, and Edward L. Deci. 2000. Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary educational psychology*, 25(1), 54-67.

- Self-Determination Theory

Gary Hsieh and Rafał Kocielnik. 2016. You Get Who You Pay for: The Impact of Incentives on Participation Bias. In Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing (CSCW '16). ACM, New York, NY, USA, 823-835.

## 2. B) Prompts in the First Evaluation

### Reading guide

Choose one of the 4 prompts below. Highlight your choice in some way. “What in the reading...”

a)	Was the most surprising concept/construct?
b)	Was something that you could use in your design practice?
c)	Inspired you to search for additional information about the theory?
d)	Addressed a real behavioral problem present in society?

Use the chosen prompt to focus on a particular aspect of the theory for the next parts of this reading exercise.

#### 1. 1. Give a catchy title to one design strategy extracted from this paper

- Action verbs are good
- Use 70 characters or less
- Use 1 minute to write down the title

#### 2. 2. Briefly explain the strategy

- 280 characters or less
- Use 3 minutes to write it down

#### 3. 3. Explain 2 or 3 real behavioral problems faced by people that this strategy can solve

- Use 140 characters or less for each
- Use 5 minutes to write down the problems

#### 4. 4. What is the specific theoretical concept/construct from theory that is connected to the recommendation above?

- Copying and pasting from the paper is ok
- Use 70 characters or less
- Use 1 minute to write down the concept/construct

#### 5. 5. Search for an image that showcases a design example that can be connected to the theoretical concept/construct drawn from the paper.

- Use 10 minutes for your search or less
- If you can't find any proper image, write below what kind of design could explain this concept to others

6. 6. Describe the image above and how it is connected to the to the theoretical concept/construct drawn from the paper.

- Use 3 minutes for your search or less
- Use 140 characters or less

7. 7. Get an image that presents the underlying insight at a conceptual level that can be connected to the theoretical concept/construct that you approached on the questions above.

- You can use keywords related to the examples of 2 or 3 real behavioral problems outlined previously
- It can't be an interface screenshot
- Use 10 minutes for your search or less
- If you can't find any proper image, write below what you think is the optimal image to explain this concept to other designers

8. 8. Describe the image above and how it is connected to the to the theoretical concept/construct drawn from the paper.

- Use 2 minutes for your search or less
- Use 140 characters or less

9. 9. Why would this strategy work to encourage behavior change? Provide a convincing argument using existing evidence. If you use data from the paper, explain what this piece of data means in practice.

- Evidence can be quotes from research participants drawn from the paper you read
- Evidence can be statistics drawn from the paper paper you read
- Or direct quotes from the paper (quoting experts)
- Use 280 characters or less
- Use 10 minutes or less to gather evidence

10. 10. What ethical concerns does the application of this theory to design raise? Reason about the occasions in which this strategy should not be applied. Explain why it shouldn't be applied, in terms of potential negative consequences of using this theory to change people's behaviors. If it should be applied carefully, how and why?

- Use 280 characters or less
- Use 10 minutes or less

#### Card creation

- Name of theory/construct. This should clearly map into information from the paper.
- Give a catchy title to one design strategy extracted from this paper. 1-minute exercise. Action verbs are good; Use 7 words or less.

- Summarize the theory-driven strategy. 3 minutes exercise. Briefly explain the strategy in 2 sentences.
- Get an image to represent the strategy at a conceptual level. You can use as search keywords the examples of 2 or 3 real behavioral problems.
- It can't be an interface screenshot
- Search for a fun or eye-catching image
- Use 10 minutes for your search or less
- If you can't find any proper image, describe in text what you think is the optimal image to explain this concept to other designers
- Credit the image.
- Describe the image and how it is connected to the to the theoretical concept/construct drawn from the paper.
- Use 2 minutes or less
- Write one short paragraph.
- Describe Dos and Don'ts to guide usage of the strategy.
- What is the recommendation for designers?
- In terms of ethics, what should designers avoid when using this strategy?
- Write a couple of bullet points for each column.
- Use 2 minutes or less
- Search for an image that showcase a design example connected to the theoretical concept/construct drawn from the paper.
- Use 10 minutes for your search or less
- If you can't find any proper image, take note of what kind of design could explain this concept to others.
- Credit the image.
- Using the design example, describe how the strategy works in this context. Use 2 minutes or less. Write 1 or 2 sentences.
- Why would this strategy work to encourage behavior change? If you are referencing a paper that contains empirical research, use data (statistics or quotes) from the paper and explain what it means in practice. If the paper does not have data, provide a convincing and logical argument for the use of your strategy.
- Use 10 minutes or less to back up your design strategy.

- Why would anyone trust that this is an appropriate way to tackle a design challenge?
- List authors and references. Add yourself as an author with links to your portfolio/blog/etc. Original paper title and authors, image credits. 1 minute.
- Review all of the content you produced for this card to reflect ethical reasoning.
- What ethical concerns does the application of this theory to design raise?
- Reason about the occasions in which this strategy should not be applied. Explain why it shouldn't be applied, in terms of potential negative consequences of using this theory to change people's behaviors. If it should be applied carefully, how and why?
- Use 10 minutes or less.
- Review your content. Make it concise. Streamline sentences that could be shorter/more precise.
- Use 10 minutes or less.

### 3. Exercises in the Second Evaluation

#### Reading guide

1. Download the weekly reading and briefly scan the document to understand the general topic. Take note of your takeaways below.	
a. Write a 140 characters tweet to describe this theory	
b. Explain how it can be useful to designers in 1 sentence	

2. Attentively read the entire document while highlighting and pasting segments below:		3. Annotate each highlight with your thoughts and/or questions
a. Words and definitions that you found interesting, or curious, or complicated		
c. Theory constructs		

d. Examples		
e. Figures, Diagrams, Flowcharts		
f. Recommendations or Takeaways		

4. Reflect on your annotations:	
a. How might this research have informed some design that you have seen? Loose connections are acceptable. Attach examples on the right and annotate them.	
b. What takeaways from this theory are relevant for your work as a UX designer or UX researcher? List a few bullet points.	

5. Finally, revise Step 1 answers after going through steps 2 and 3.

*Important: The crucial part is to put an intellectual effort in your reading and note-taking. Do not create a simple paper summary.*

**Peer discussion (1 hour)**

1. Break into pairs to discuss this week's 2 readings. (10 minutes)
2. Brainstorm design strategies based on each theory and list them below. (5 minutes)
  - a. Draw on the content that you produced for the Active reading exercise.
  - b. Important: Design strategies are specific, not general assertions of what the theory is!

- Now, each of you will create one card. Choose 1 strategy from each column using the prompts below to examine options. (*5 minutes*)
- Most surprising or interesting concepts/constructs/strategies
- Something practical that you could use in your design practice
- Addresses a crucial behavioral problem present in society

## Card creation

Front of the card

1. Give a catchy title to one design strategy extracted from the paper

Action verbs are good; Use 7 words or less. Reference 1a and 1b parts of the reading guide.

2. Summarize the strategy

Briefly explain the strategy in 2 or 3 sentences.

Reference 1a and 1b parts of the reading guide.

3. Search for an image to represent the strategy:

- You can use keywords highlighted on the reading guide (step 2) as search keywords on Google Images, Behance, Dribbble, [Unsplash](#).

- Search for a fun or eye-catching image

- Credit the image in the back.

4. Describe the image and how it is connected to the to the theoretical concept/construct drawn from the paper.

- 1 paragraph.

5. Recommend Dos and Don'ts to guide usage of the strategy.

- Reference step 2f and 3b of the reading guide.
- Craft recommendations that are actionable. What should a designer do right now to improve their process based on your reading of the paper?
- Recommendations can be advice on how to specifically design features, or methods to discover how to design them following insights from the reading.

Back of the card

1. Name of theory/construct

This should clearly map into information from the paper.

2. Title (use the same title from the other side of the card).

3. Search for an image that showcase a design example connected to the theoretical concept/construct drawn from the paper.

Reference step 3a from the reading guide.

You can also build a prototype to display your idea.

4. Using the design example, describe how the strategy works in this context.

- Write 1 or 2 sentences.

5. In terms of ethics, what should designers avoid when using this strategy? What are the potential ethical implications of how you intend to influence behavior change with this strategy?

6. Authors and references