Prototyping with Co-designers to Imagine Future Experiences

Thesis
Presented in Partial Fulfillment of the Requirements for the Degree Master of Fine Arts
in the Graduate School of The Ohio State University

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The Ohio State University
2016

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Abstract

Today’s designers are tasked with going beyond products and graphics to create new experiences and services that thoughtfully consider the entire system of touchpoints and interactions. This new scope often requires designers to work across the research and design phases together with key stakeholders in order to gain a holistic view and generate solutions that address shared concerns.

As a designer that was trained with a modernist set of design skills, I was curious to understand what parts of my experience as a product designer would help me be successful when tacking these complex concerns, and what new skills I might have to learn.

In order to take on the challenge of designing for complex concerns, I chose to adopt a new design approach, learn new roles and utilize new media. My approach shifted from a modernist design approach (collaborating with peers and mentors) to a co-design approach (collaborating with stakeholders, peers, mentors). My role changed from a furniture designer to a design researcher. And finally, the materials and medium moved from prototyping and making physical objects to prototyping experience and systems with people.

With this direction, I explored how my design skills such as sketching, prototyping and making could be used to understand experience and systems and help to engage multiple stakeholders with different perspectives as co-designers around a shared
complex problem (reimagining Introductory Physics) to inform and inspire the co-design process. I used a research through co-design approach so that I could gain first-hand experience of the new considerations.

I conducted a series of interviews, co-creation workshops and iterative prototyping with a small, select group of stakeholders (co-designers) to generate new ideas and understanding of what the future learning experience for an Introductory Physics student at The Ohio State University might be. I developed a greater understanding of the co-design process and the roles the designer, co-designer and prototypes play.

The outcome of this study points towards new and emerging roles that designers and researchers should consider if they are to engage in the practice of co-design, how prototypes can support early ideation and continued involvement by co-designers, and the benefits of working with a mixed group of stakeholders in a participatory manner that actively engages the co-designers to create and critically think.
Dedication

This thesis is dedicated to my parents. My Dad, for my strong work ethic and self-belief; my Mum, for my spirit of adventure and curiosity. For always supporting me with love and encouragement. And of course my Granny, for your wonderful love, letters and sense of humour.
Acknowledgements

I would like to take this opportunity to sincerely thank my main advisor and mentor Dr. Elizabeth Sanders. Having the opportunity to work with you has not only shaped the outcome of my time as a graduate student, but my outlook and direction moving forward into the world of design research. To work with someone with such energy, clarity and vision has been the definite highlight of my time here at OSU.

I would also like to thank my advisor Maria Palazzi. From the first day I was in your class you have pushed me to improve and expand my design abilities and strive to raise the quality and clarity of my work. I am very grateful to all of the support from ACCAD that allowed me to explore new areas of design and technology that I knew very little about before arriving in Columbus.

I would also like to thank my third committee member, Dr. Andrew Heckler, for your continuous support of my co-design efforts with Physics Research Education and the student experience that I know you are so passionate about. This collaboration would have not been possible without Henry Griffy and all the faculty, staff and student co-designers that participated in the process.

I am grateful to all my peers for their feedback and viewpoints that have helped inform my own. I would especially like to thank my good friend and collaborator Darwin Muljono for the crazy amount of work we did together and for your help in shaping my
own design ideals. I would also like to thank David Staley for our future-focused
discussions around universities and lunchtime kick-a-rounds!

Finally, I would like to thank the Department of Design and the Graduate School
for supporting me during my two-year stay here at OSU. It has been both rewarding and
life-changing, and entirely inaccessible if self-funded.
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Fields of Study

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Chapter 1: Introduction

“It isn’t just about the chair anymore.” - (from conversation) Pieter Jan Stappers, 2015

1.1: My Research Motivations

Through my abilities as a maker and designer, I communicated my ideas to the world through artifacts and objects, through sketches, mock-ups, prototypes and renders. This made a lot of sense when I was designing and making physical artifacts such as furniture and products for clients. However, today’s designers and researchers are being tasked to tackle complex problems that are multifaceted, often existing in both physical and virtual worlds. These intangible systems and experiences become harder to imagine from an individual, or collective, perspective without tangible materials to actively use to describe what a proposed experience might be like.

That is not to say that my skills learned as a practicing designer are obsolete. Nor that designer of tangible artifacts will become obsolete. The foundation of this thesis is built on the value that these learned skills have as excellent communication tools for new experiences yet to become reality. This value was evident in my study and is supported by the work of other designers and practitioners. Not just for internal critique amongst fellow designers, but to communicate and actively engage with a broader stakeholder group; a group that needs to be brought into the process in order to understand and respond to complex problems.
As a practicing designer I know that in going through the design process, the communication and interpretation of ideas can generate new ideas. The creative process is fluid. Creativity is not a hard science. I believe to be a successful creative you have to accept (even embrace) the ambiguity, the ‘fuzziness’, of the front-end of the design process in order to create truly new and unique outcomes.

With my thesis as the driver, I was determined to gain first-hand experience of the generative design research process and contribute to my field by reflecting on my own discoveries and insights from a designer’s perspective. I believe I gained that first-hand, practice-based experience, and I hope my own observations and reflections can add to the discussion surrounding the emerging roles that designers are finding in the space between research and design and in the tackling of complex problems.

1.2: Problem Statement

Over the past 20 years design research has expanded to include designers and engineers searching for inspiration and insight, in addition to researchers. The introduction of technical skills, such as prototyping, means more ‘designed’ materials and objects entering the field of qualitative research. “This new generation [of design researchers] have been trained in design, making them not only keen to undertake research with holistic qualities and to seek out knowledge which is highly relevant for application by design(ers), but also to apply the methods and techniques from design to use in a research project.” (Stappers, 2013) This approach of designers working in tandem with the stakeholders they are designing with is referred to as co-design. Co-
design means designing with people, instead of for people. (Sanders & Stappers, 2014)

These people can be referred to as ‘experts of experience’, meaning that they have a wealth of knowledge about a given area based on their own first-hand experience.

The designer may take on several roles during this process. In my research I have been a facilitator, interpreter and provocateur, guiding experts of experience to work individually and together to create new ideas that can meet their personal and shared needs. This approach to design emerged from the practice of Participatory Design, which allows the people who will benefit from the design to directly influence what ideas and solutions are generated. A more sustained engagement with stakeholders is required as co-designers become more involved in the entire design process.

Iterative prototyping has traditionally enabled designers to test concepts in the latter stages of development once problems and proposed solutions have been defined. Exploring the use of iterative prototyping to stimulate interaction and discovery during co-design, on the other hand, has the potential to generate insightful, stakeholder-driven ideas and consideration. Currently, startups and other businesses have embraced iterative prototyping (e.g. lean, agile) when developing new products and services. These processes are fast and inexpensive methods of development. These ‘prototypes’ are often used to explore the look and feel or implementation (Houde & Hill, 1997) of a product, but what if these methods were applied to the front-end of the design process in order to explore stakeholder understanding and ideation, before the role of the product is defined?

This proposed means of co-designing through prototyping becomes increasingly important as complex problems require designing with multiple stakeholders to create beyond the immediate object, touch point or interface and consider the entire system or
service. There is an increasing need for methods that allow people to actively think, create, enact and question near-future concerns that are currently not always thoughtfully considered. Providing a process that can build “not mega-utopias defined from the top down but seven billion little utopias emerging from the bottom up, facilitated by, not determined by, design.” (Dunne & Raby, 2014)

1.3: Aim and Scope

This study aims to combine the strengths of co-design and iterative prototype development to engage stakeholders to generate ideas on future experiences. Through this process, I hope to gain a unique perspective on how a designer can contribute to the generative co-design research process and add my own voice to the designer role discussion. This can inform how prototyping with co-designers can generate and communicate ideas and opportunities. The process will also help inform how co-design can be supported by prototyping and if the same tools can be applied to other complex concerns in the future.

As a case study central to my thesis, I will engage with stakeholders connected to Physics Education Research at The Ohio State University in order to answer my research questions based on first-hand experience. My answers will also be supported by parallel research and exploration from other designers in academia and practice.

An iterative series of interviews and workshops will guide the participants to explore, generate and develop ideas using prototypes to explore the future learning experience of Introductory Physics from the student perspective. The research hopes to
benefit from the shared perspectives of students, faculty, instructors and administrators when imagining the future learning experience.

1.4: Thesis Overview

1.4.1: Research Questions

Firstly, what are the roles of the designer (and the co-designers) in the co-design process? How can prototypes be used to generate new ideas and reflect on the proposed experience? How can co-designers be supported to collectively prototype an engaging experience that meets their future needs and goals? How can co-designers remain as active voices as the design process moves into development?

1.4.2: Research through Co-design

When I first started this research, I self-identified as a designer/maker. The area of ‘Research through Design’ (Zimmerman & Forlizzi, 2007) made a lot of sense to me. Exploration, reflection and discovery through the act of making is an approach that I chose to adopt. As I learned more about Participatory Design (Co-design) through the act of doing, making and learning with co-designers, I realized that writing from the perspective of a designer doing research through the co-design process would personally allow me to engage with the questions I had to generate new knowledge on the roles of the designer in the field of co-design and co-designers.
1.4.3: Audience

I want this thesis to inform and generate discussion and debate amongst fellow designers, researchers and those who are also exploring the space between design and research working with a participatory/co-design mindset. Due to the educational theme of my case study, this research may also be of interest to those researching within the Learning Sciences. Learning scientists work on the design and implementation of real-world educational environments and systems. (Nathan & Sawyer, 2014) From my experience, methods used in participatory design can help support stakeholder conversation and the creation of new learning experiences that put the student at the center of the discussion.

1.4.4: Terminology

To help accurately communicate in the following chapters, this chapter will outline key terms and provide definitions. The alphabetized list below covers all the key terms that will be used throughout the thesis:

**Co-creation** - “any act of collective creativity, i.e., creativity that is shared by two or more people” (Sanders & Stappers, 2008)

**Co-design** - “collective creativity as it is applied across the whole span of a design process” (Sanders & Stappers, 2008)

**Co-designer** - an end-user or other stakeholder that is involved in the act of collective creativity across the design process.
**Concept** - the result of a transformation of existing ideas into one cohesive representation.

**Critical design** - takes a critical theory based approach to design. This kind of design uses speculative proposals to challenge assumptions and conceptions about the role that objects could play in everyday life.

**Design fiction** - a method of critical design that uses fictional and narrative scenarios to envision, explain and raise questions about possible futures for design and for society.

**Design-driven innovation** - is radical innovation of meaning. Not achieved by technological leaps or user-centered iteration, but by placing emphasis on emotional, psychological, and sociocultural reasons of use. (Verganti, 2009)

**Human-centered** - a mindset that places people and their needs at the center of the thought process for solving problems. This approach places a higher value on the perspectives and input of those that are being designed for and/or with than a user-centered approach.

**Idea** - a mental conception that exists as a result of understanding, awareness, or activity.

**Prototype** - “a story or a fictional depiction of a product [service, experience, etc.]. The prototype is not the actual thing that we want to build; it is an example, a rough approximation of the thing we hope to one day build.” (Johnson, 2011)

**Provotype** - a provocative prototype - introduces designer-made objects into the early phases of the design research process in order to provoke and engage people to imagine future possibilities
**Stakeholders** - Persons, groups or organizations that have direct or indirect stake in an organization because they can affect or be affected by the organization’s actions, objectives and policies

**Sense making** - “an action oriented cycle that people continually and fairly automatically go through in order to integrate experiences into their understanding of the world around them.” (Kolko, 2010)

**Sketch** - a rough or unfinished drawing/prototype

**User-centered** - a framework of processes in which the needs, wants, and limitations of end users of a product, service or process are given extensive attention at each stage of the design process.
Chapter 2: Background

“The practice of making is a route to discovery” - Bill Gaver

2.1: My Background Focus

To understand the direction of this study it is important for you to understand a little bit more about me as a designer. My path to Design Research started in Mechanical Engineering, before taking a seven-year turn into Product and Furniture Design to eventually arrive at my current career destination of Design Research.

My undergraduate design schooling was a fairly traditional one. Design was taught through project-based learning. Every project was different but our design approach; role and materials remained the same throughout. It was purely about the object. We were often given a brief that was predefined (e.g., Design a reception desk for a local art gallery for under four-hundred pounds). The ability to sketch and prototype, model and render, deliver and present was the core focus. Upon graduation I worked at a Design firm, applying these skills to commercial furniture projects. The approach was user-centered design, my role was as a designer/maker and the materials ranged in fidelity but were always used to represent physical objects to inform the final design. I worked with clients to understand their needs and define a brief, or would be handed over a brief to follow.
Coming back to gain my Masters degree was an opportunity for me to reposition myself as a Design Researcher with a focus on designing for experience, service and systems. To do this would mean learning a new approach, stepping into new roles and working with new materials to prototype and create. These three themes thus became the focus of this background investigation. I wanted to gain a deep understanding of what I could carry over from my previous design practice and what new skills I might have to learn in order to successfully create new and meaningful experiences.

In my practice, I considered prototyping to be my most effective tool to communicate my ideas to peers or mentors. This chapter will first define and briefly expand upon my chosen approach and roles of the designer and co-designers before focusing on prototypes to understand their current and future uses as research and design learning tools.
2.2: The Design Approach

2.2.1: Co-design Process

Here I will define co-design as an approach and process within the context of this research project. The design landscape is filled with different approaches, methodologies, methods and tools that a designer can use on any given project. However, as designers begin to look beyond the immediate product and are tasked with designing for experience, service or even organizational change (Coughlan, 2007), some of these methodologies and methods become inappropriate as they fail to either communicate or frame the discussion in a meaningful way.

When dealing with complex problems that involve multiple people, touch points and systems an approach is required that brings the different people and their unique perspectives together so new ideas can be created that are valuable and collectively address their unmet needs. Design thinking and co-design are both processes that offer a means to tackle complex problems. I will define both terms, then compare them to establish the difference between the two approaches and why I chose to use co-design.

Co-design can be defined as “collective creativity as it is applied across the whole span of a design process.” (Sanders and Stappers, 2008) While design thinking is defined as “a user-centered and teamwork-based approach that solves problems in an iterative way.” (Stanford d.school, 2010)

From my perspective, the similarities are found in that both apply an iterative design process that stems from the traditional design approach and both are collaborative practices where team-work is involved. The main difference is that the co-design process
invites those that will benefit from the design into the iterative process as active members of the design team, from beginning to end, as opposed to their serving as research participants or user testers. These stakeholders are given an equal seat at the table as they are the experts of their own experience (Sleeswijk Visser et al., 2009). Iteration is a very important aspect of the co-design process as this enables co-designers to share information and inspiration, build collaborative connections and transform ideas into tangible outcomes.

In the context of my research, a big advantage of taking this approach is that, through the process of co-creation, the perspective shifts from a product centric focus to an experience centric focus (Prahalad & Ramaswamy, 2004). Another factor is time. Coming from the outside into a complex problem or situation requires a lot of time and energy to gain a true understanding of all the moving parts and actors in play. The truth is that even the people on the inside may struggle to understand and explain every aspect of the problem in a holistic manner. Engaging stakeholders from across the problem space to come together and share their collective knowledge is necessary to create ideas and outcomes that can be useful and meet actual needs.

### 2.2.2: Research through co-design

I conducted research through co-design in order to understand the different roles first-hand that a designer has to take on and to experiment with different prototyping methods and tools in the co-design process. “Researchers make prototypes, products and models to codify their own understanding of a particular situation and to provide a concrete framing of the problem and a description of a proposed, preferred state…”
Designers focus on the creation of artifacts through a process of disciplined imagination, because artifacts they make both reveal and become embodiments of possible futures.” (Zimmerman & Forlizzi, 2007) Taking this Research through Design approach to my investigation would allow me to explore and answer my research questions through reflection and discussion of my first-hand experiences so as to share them with the wider design community.

2.3: The Roles of Designer and Co-designers

Before addressing the changing role of the prototype I want to first explore with you the role of the designer in the process of co-design and the different hats that a designer may wear throughout this process. In the process of co-design, the designer may act as a research facilitator, provocateur, interpreter, sensemaker and form giver. The co-designer is viewed as an expert of their own personal experience and potentially their field of expertise. The roles of the designer and co-designers change as they go through the design process. “As the term co-design suggests, ideas are not generated by the users, designers or researcher alone but in the interaction between several people representing different backgrounds and skills.” (Vaajakallio, 2014)

2.4: The Applicable Skills of the Designer

The roles a designer plays in the co-design process are not limited to a single point in the design process. “By selection and training, most designers are good at visual thinking, conducting creative processes, finding missing information, and being able to make necessary decisions in the absence of complete information. In the near future,
designers will find themselves involved not only in the design of stand-alone products but in the design of environments and systems.” (Sanders and Stappers, 2008)

2.5: The Roles of the Designer

2.5.1: Designer as Facilitator

The designer facilitates the co-creative design practice by creating materials, prompts and scaffolds to be used during collaborative sessions to support co-designers of varying levels of creativity. Understanding how much structure to provide is key to empowering co-designers to be successful creatives. The designer can also be the facilitator of the collaborative session, guiding the stakeholders through the design process. At this level of facilitation, the designer will also have to build relationships with co-designers while establishing and managing the scope, scale and expectations for the overall project and outcomes of each session.

2.5.2: Designer as Sense Maker

Being closely involved in the process of research enables the designer to make connections and generate ideas. “While used throughout the process of design, synthesis is most commonly conducted at a precarious moment between research and definition.” (Kolko, 2012) The intent of designer is to inform the design of a new artifact, but the data itself does nothing to inform design, as data is inactive and lacking context (Shedroff, 2001). The designer must make sense of the data to actively inform the design. It is at this moment that design synthesis occurs, through an implicit and explicit series of actions the
designer is able to generate ideas by making multiple hypothesis as a form of inference. (Peirce, 1998)

2.5.3: Designer as Form Giver

The designer’s ability as a form giver, from a traditional perspective, is leveraged to provide physical manifestations that co-designers can use to express their needs and barriers, hopes and fears. “Models and prototypes have been instrumental over the past 10 years, in creating advanced representations and forms to connect better with the expectations of the different stakeholders. Hereby, the designer plays a key role in shaping the (physical) representations, which then can be distributed to non-designers to imagine future objects, future experiences and future ways of living.” (Isa & Liem, 2015) This is true in the beginning of the co-design process when generating ideas, but becomes even more important later in the process when communicating with the outside world. (Rhinow, 2013)

2.5.4: Designer as Provocateur

While the designer can create and provide a toolkit of objects or stimuli to support collaboration amongst co-designers, the designer can also introduce provocative objects or provotypes, into co-design sessions to elicit reactions or test hypotheses. (Boer, 2012; McKenzie, 2015) This approach can become particularly powerful if the engagement is in a home environment because the designed object can be engaged with in the intended environment of use or in public space as it encourages critical thought on behalf of the observer (Buur, 2007; Dunne & Raby, 2001). This role within design research is an emerging one and could potentially bridge the human-centered and design driven
approaches to research and design development. Design fiction is another area where
designers are using their design skills, not to meet a commercial demand, but to provoke
discussion surrounding a cultural, societal or environmental concern (Dunne & Raby,
2013). However, these provocations are now often found in design museums or art spaces
so they don’t offer the same level of engagement that the aforementioned provotypes
might offer.

2.6: The Roles of the Co-designer

The roles of the co-designers include being active collaborators, experts of
experience and experts in their own field or practice. Their individual perspectives and
experiences are unique. When existing in a system, such as Intro Physics, these
perspectives can be combined together to give a greater, more holistic picture of the
complex system at work. By bringing these different people with different experiences
together we can start to understand how a sociotechnical system works as told from what
is happening ‘on the ground’. These combined perspectives can inform a system view
based on actual events, not only through assumed or observed experience. Also, through
having different perspectives represented, different stakeholders have the opportunity to
understand and learn about other perspectives.

2.7: The Changing Roles and Applications of Prototyping

Prototyping is certainly a design method used extensively in the traditional design
process when focusing on products. In this section, the term ‘prototype’ will be addressed
and defined within the context of the study. I will then consider how prototypes have
been traditionally used, how the reader (and author) might alternatively perceive and interact with prototypes, and how prototypes are taking on new roles in the front end of the design process.

Understanding how the introduction of design methods and techniques will impact co-design is a complex, yet valuable consideration. Thankfully, these methods and techniques can be taken apart and examined in more detail to understand the relevance of their appearance in the realm of co-design. Therefore, focusing on the role of the prototype in co-design will hopefully give some indication as to the impact that designerly ways of knowing (Cross, 2001) might have on the field and what might still need to be understood. “Prototyping is core to how designers do their work. It involves moving from the world of abstract ideas, analysis, theories, plans, and specifications to the world of concrete, tangible, and experiential things.” (Coughlan, 2007) As Design Thinking becomes increasingly used to tackle complex problems, new forms of prototyping must be considered to support multiple stakeholders coming together to share their unique perspectives and co-create new ideas and solutions in the front-end.

2.7.1: Definition of Prototype

“There is a lot of debate as to what a prototype actually is. The word prototype has different meanings, depending upon the business or market you are talking about. A prototype in software design is wildly different than a prototype to the automotive industry.” (Johnson, 2011) Brian David Johnson of Intel raises the point that defining where the term ‘prototype’ is used, and to what ends, is important. The focus of this investigation will use prototypes in the front-end of the co-design process to generate and
develop new ideas with stakeholders to understand what an ideal experience might look and feel like.

**Figure 1:** Houde and Hill’s diagram visualizing traditional prototype use.

Houde and Hill define three areas of role, look and feel, and implementation (see figure 1) that prototypes are traditionally used within to ideate, understand and evaluate. These areas triangulate to inform the final “integration” that becomes an artifact (or product). They believe that almost anything can be purposed (or re-purposed) to act as a prototype. Considerations such as material, form, fidelity, audience and presentation are all important factors when creating a prototype, but the intent of the prototype, defined by the designer, is critical. “What is significant is not what media or tools are used to create them, but how they are used by a designer to explore or demonstrate some aspect of the future artifact.” (Houde & Hill, 1997) This is further supported by Lim and Stolterman, “A ‘good’ prototype can only be understood in relation to the specific purpose of the
design process and to the specific issue that the designer is trying to explore, evaluate or understand.” (Y. K. Lim et al., 2003)

To paraphrase Houde and Hill, materiality must be taken into consideration in connection to what the prototype is trying to achieve, but it is ultimately the purpose that defines the prototype and, thereafter, the perceived use. This investigation will focus on how prototypes are finding new uses in academia and practice, but will not explore in detail the material nature of prototypes. A prototype can be defined as “any representation of a design idea, regardless of medium” (Houde & Hill, 1997).

Brian Johnson’s definition opens up the term ‘prototype’ to other potentials and will be the definition used throughout this study when referring to ‘prototype’. “A prototype is a story or a fictional depiction of a product [service, experience, etc.]. The prototype is not the actual thing that we want to build; it is an example, a rough approximation of the thing we hope to one day build.” (Johnson, 2011) Taken in this sense, even a sketch could be defined as a prototype if presented and engaged with in the right context.

Prototypes have the potential to act as engaging objects for co-designers to ideate around in the front-end of the design process. In the traditional process of design, prototypes are used to inform and evaluate design decisions. However, prototyping in the front-end of the design process could engage stakeholders with “objects whose function is not to test or prove, but which provoke reflection, experimentation and discussion” (Mogensen, 1992), making stuff to make sense of the future (Sanders & Stappers, 2014) by interpreting objects as “matters of concern, not matters of fact.” (Latour, 2008) This could mean designer-made ideas or objects presented to co-designers, or co-designers
creating prototypes to convey their own ideas. Can prototypes be used as a tangible focal point or to frame a discussion about a future *experience or system*?

### 2.7.2: Subjective Role of Objects/Prototypes

Before focusing on the different applications of prototypes as they are being used today, I wanted to take a more philosophical approach to objects and their subjectivity by exploring the positions of Heidegger and Latour. What I took away from both was that Houde and Hill’s statement is true, that the medium really can’t be the focus when using low-fidelity materials to prototype and generate ideas in the front-end. How the materials are presented in the context of use becomes the means for a designer to control the outcome, as our engagement with materials is different for everyone.

Heidegger uses the void within a handcrafted jug to contemplate how he distinguishes between object and thing, eventually suggesting that things, much like time, are subjective experiences. Today, this perspective is perpetuated by faster methods of communication, transportation and information delivery, meaning that our relationship to things is more subjective than ever. (Heidegger, 1971)

The search for alternative interpretations of objects was certainly ignited by Heidegger’s work that ponders our understanding of what an object truly is when we experience it only within certain frameworks of visuality, tactility, and temporality. It can be difficult to consider objects beyond their material or practical worth, but frameworks that encourage participants to engage with things, not objects, could inform a discussion that begins with a tangible thing, but explores beyond the boundaries of the prototype and into less tangible areas of discussion such as experience. This act of viewing objects
subjectively as things is critical for the author of the prototypes to understand, a
relationship that is further elaborated on by Latour.

Bruno Latour further develops this philosophical approach to design and lays
down markers for how we can interpret Heidegger’s things as matters as concern, not the
modernist matters of fact. “If it is true as I have claimed that we have never been
modern, and if it is true, as a consequence, that “matters of fact” have now clearly
become “matters of concern”, then there is logic to the following observation: the
typically modernist divide between materiality on the one hand and design on the other is
slowly being dissolved away. The more objects are turned into things – that is, the more
matters of facts are turned into matters of concern – the more they are rendered into
objects of design through and through.” (Latour, 2008)

Latour suggests that a move away from the modernist view of objects will lead to
more alternative interpretations of things. However, can designers redefine the role of the
prototype to communicate matters of concern with an audience that lives beyond the
realm of design? Latour seems to not only support the idea of exploring matters of
concern through newly reimagined prototypes, but also that all things are a result of
“collaborative design”. (Latour, 2008)

“If things, or rather Dinge, are gatherings, as Heidegger used to define them, then
it is a short step from there to considering all things as the result of an activity called
“collaborative design” in Scandinavia. This activity is in fact the very definition of the
politics of matters of concern since all designs are “collaborative” designs – even if in
some cases the “collaborators” are not all visible, welcomed or willing.” (Latour, 2008)
Engaging with new audience members (non-designers) will mean establishing more engaging tools in the front-end of the design process to connect stakeholders and encourage collective ideation around matters of concern. According to Latour, these tools will evolve from current design practices redefined to enable reflection on matters of concern. This alternative perception of things is certainly valuable and perhaps attainable through the design practice of prototyping. Redefining prototypes as things will involve a more conscious awareness by the designer, a more philosophical engagement with participants and a new definition of prototype. “What is needed instead are tools that capture what have always been the hidden practices of modernist innovations: objects have always been projects; matters of fact have always been matters of concern.” (Latour, 2008) This ability for objects to be viewed as matters of concern, also introduces the notion of *experience*. “The design of things [become] matters of concern and possibilities of experience.” (Ehn, 2008)

### 2.7.3: Prototypes that Engage and Support People to Generate Ideas

Recent project-based research that engages participants with prototypes, objects or artifacts in a participatory setting needs to be investigated to inform considerations, outcomes and best practices. These early academic explorations support the use of prototypes as catalysts or conduits for discussion and speculation amongst individuals and stakeholders. “This work demonstrates that creativity-driven workshops and physical artifacts are effective tools in encouraging the generation of requirements and solutions for *complex problems.*” (Newman, 2015)
Matt Ratto’s Critical Making serves as an example of subjective interaction with things to explore matters of concern. His case study explores how Arduino-based systems, that can be built to interact with each other, generate discussion amongst participant builders on our conflicting relationship with technologies and how making can connect the technical and social worlds that are interpreted by Latour as fact and concern. In this series of experiments, making the objects acts as a catalyst for the conversations related to these matters of concern. Much like a prototype, what is physically created is of little value. Ratto believes that making is a critical component to nurture conversations on matters of concern.

“What makes the ‘flwr project’ understandable is making. Without material engagement in the project of building and configuring a flwr it is easy to view the resultant objects as an interesting (or uninteresting) illustration of technical possibilities or of social theory but ultimately limited in their ability to innovate either one.” (Ratto, 2008) Ratto insists that actively engaging with low-fidelity materials can stimulate discussions around matters of concern. “When things are taken as having been well or badly designed then they no longer appear as matters of fact. So as their appearance as matters of fact weakens, their place among the many matters of concern that are at issue is strengthened.” (Ratto, 2008)

However, Ratto also recognizes the problems and limitations with this type of low fidelity making and discussion. “It remained (and remains) quite easy for external viewers to misunderstand either the intention of the exercise or the relevance of its results without extended commentary such as this article.” (Ratto, 2008)
Designer-made, high fidelity artifacts that are able to express the concerns discussed in the context of the low fidelity making sessions could prove to be a more provocative and engaging means to communicate the relevance of the results to outsiders. Artifacts informed by these discussions could act as a bridge between the workshop sessions and written documentation. “What is unique to this approach to design research is that it stresses design artifacts as outcomes that can transform the world from its current state to a preferred state.” (Ratto, 2008)

Critical Making enables people to engage with things that stimulate a discussion beyond matters of fact, and explore matters of concern through making. This requires the academic participants to reconsider the role of the object as more than what is placed in front of them. The relationship between author, prototype and reader could potentially support speculation and discussion in participatory design around less physically tangible and immediate concerns. Taking small things to think about big issues. “Props require a shift in the role of the viewer, too; they become active ‘imaginers’.”(Dunne & Raby, 2012) If taken a step further in a participatory setting, viewers become imaginers, become creators, and become owners. And with ownership comes a greater understanding of, and reflection on, the future.

Provocative prototypes, or provotypes, (Boer, 2012) are informed by initial engagement and ideation with stakeholders in a participatory setting, after which high fidelity artifacts are produced. The provotype is then introduced into the end-user’s home environment for an extended time to generate insight, gathered through interviews that those living with the artifacts can learn from. This situational engagement is designed for provocation as the function of the artifacts is not divulged to the participants until after
the situational experience is over. This uninformed participation method can be contrasted with the informed use of multiple artifacts in an exhibition-like setting that aims to make employees consider future scenarios through prototype interaction and reflection. “The difference with other methods that achieve user insight through artifacts is that through the provotype method [participants] are made to reflect on a new experience they get with the provotype itself.” (Botermans, n.d.)

If participants were actively involved in the creation, implementation and reflection process, would that generate ‘experiential’ understanding, awareness, and new ideas? Could engaging stakeholders through prototype iteration and discussion lead to reflection on the impact of what is collectively created? Can front-end prototypes act as catalysts for ideation? Or does presenting the user with concepts stifle their ability to ideate or support the creative leap?

A recent study at Lancaster University investigating Physical Prototyping for Social Software Engineering (on the Isle of Tippee off the West coast of Scotland of all places) coined the term “Diving Board” to describe their use of participatory prototype iteration to elicit ideation and conversation around the topic of renewable energy on the island. Diving Board “facilitates the exploration of the problem domain with the participants through a number of creative workshops, interviews, and meetings with stakeholders and other members of the community. Once a number of high level themes and ideas are elicited from the community, the process then involves the creation of a number of prototypes that represent the aforementioned ideas. These ideas are then presented back to the participants for critical reflection and refinement.” (Newman, 2015). This process was then fed back into an iterative loop in order to develop a
deployable app as the final artifact. This study confirms that prototypes can be used to explore ideas beyond the immediate object. The purpose of the iterative process was to develop a final product, as opposed to generating richer ideation and speculation.

Buchenau and Suri place emphasis on the experiential aspect of whatever representations are needed to successfully (re)live or convey an experience with a product, space or system. The authors also recognize the value of “methods and techniques which support active participation to provide a relevant subjective experience” (Buchenau & Suri, 2000) that aligns with Latour and Heidegger.

“The experience of even simple artifacts does not exist in a vacuum but, rather, in dynamic relationship with other people, places and objects.” (Buchenau & Suri, 2000) This indicates that not only the tangible object needs to be considered, but the experience of use for the user. Experience prototyping has the potential to involve scenarios or storyboards to good effect. This raises the consideration of narrative once again to convey more than the immediate object to participants.

Houde and Hill’s earlier defined role of prototyping is tentatively expanded upon to include the “contextual factors” that surround anything. Inevitably we find ourselves asking questions about the "role" which Houde and Hill define as “the functions that an artifact serves in a user’s life — the way in which it is useful to them.” And even more than this, when we consider experience we must be aware of the important influences of contextual factors, such as social circumstances, time pressures, environmental conditions, etc. Generative, front-end prototyping that exposes participants to the contextual concerns of experience could elicit more informed and insightful ideation while identifying unmet needs.
Speculative Everything (Dunne and Raby, 2014) introduces speculative design by discussing a gathered assortment of what the authors consider successful works that fall under the category of “conceptual design” or critical design. The authors explore different categories of fiction, with examples acting as springboards for visually rich conversations about the purpose, application and future use of critical design. Dunne and Raby suggest that the provocative nature of speculative design can act as a lens (catalyst) for individuals to imagine and discuss very different futures.

“The space between reality and the impossible, a space of dreams, hopes, and fears. Usually this space is occupied by future forecasts (commercial world), design scenarios (corporate world) and utopias and dystopias (literary and cinematic worlds). It’s an important space, a place where the future can be debated and discussed before it happens, so that, at least in theory, the most desirable futures can be aimed for and the least desirable avoided.” (Dunne & Raby, 2011) This quote from “What If...” by Anthony Dunne and Fiona Raby epitomizes the space that participatory design and critical design share. Application and discovery of a ‘space to dream’ is approached from very different perspectives by both methodologies, but the same intent prevails. The use of objects or artifacts is more commonplace in critical design, but various forms of making and enacting can be observed in participatory design. There is however more making and producing in participatory design by non-designers than can be found in critical design, where the designer is often the sole author.

Design noir placebos are artifacts that volunteer participants lived with to encourage a reflective experience on electronic objects and the invisible electromagnetic waves that connect them. “We devised and made eight prototype objects to investigate
people’s attitudes and experiences of electromagnetic fields in the home, and placed them with volunteers.” (Dunne & Raby, 2001)

Participants were informed about the objects before they lived with them. This created a situational form of role-play and engagement that generated interesting reflection by the participants on the role of electronics in their home. This reflection was captured through interviews and photography. However, what if the participants and designers had then collectively ideated to express these newly considered needs? This approach of situational role-play with speculative artifacts could potentially provoke participants to actively think about their relationship with a certain place or experience in the future. Critical design that reaches beyond the boundaries of design, becoming more democratized, can enable objects to empower or provoke. To achieve this, Matt Malpass believes that the field of critical design has to engage the greater public in a more thoughtful way.

*Between Wit and Reason* by Matt Malpass trumpets a call to action for critical design to be more thoughtfully considered to better engage with a wider audience and establish the field beyond design for designers. “More and more, the danger is that critical practice becomes overly self-reflexive and introverted, sustained, practiced, and exchanged in a closed community. By operating in this way, its usefulness as part of a larger disciplinary project is undermined.” (Malpass, 2013)

Malpass provides a compelling guide to understanding and introducing speculative artifacts or objects that engage with participants beyond design. “There is no satire without critique, and humor is a powerful tool of engagement. But this critique is contingent on reading the objects of critical practice as objects of design. These are,
therefore, always contextualized and rationalized with a narrative of use. The critical move is established in the uncanny marriage of wit and reason that resonates with the user, causing a dilemma of interpretation and questions to be asked of the design and the contexts addressed in the work.” (Malpass, 2013) According to Malpass, narrative that evokes playful elements of wit and reason can support the use of provocational things in the participatory front-end.

2.8: Conclusion

To conclude, this chapter explored how the reader (and author) might alternatively perceive and interact with prototypes, how prototypes might promote speculation and discussion, and how prototyping can be engaged in the front end of the design process.

According to Latour, tools can evolve from current design practices redefined to enable reflection on matters of concern. This alternative perception of things is certainly valuable and perhaps attainable through the design practice of prototyping. Redefining prototypes as things will require a more philosophical engagement by participants and more conscious awareness by the designer.

Alternatively perceiving and interacting with prototypes can certainly be facilitated using some of the ideas, guidelines and methods explored throughout this paper. Low-fidelity materials can certainly stimulate discussions around matters of concern, as demonstrated by Peter Newman. However, frameworks that encourage participants to engage with Heidegger’s things, not objects, could further inform a discussion that begins with a tangible thing, but explores beyond the boundaries of the
prototype and into less tangible areas of discussion such as experience. Prototyping Experience perhaps comes closest to enabling participants to ideate and reflect on the contextual concerns that every object holds.

    Situational role-play with speculative artifacts could potentially provoke participants to actively think about their relationship with a certain place or experience in the future. If participants were actively involved in the creation, implementation and reflection process, would that generate ‘experiential’ understanding, awareness, and new ideas? Could engaging stakeholders through prototype iteration and discussion lead to reflection on the impact of what is collectively created?

    Using prototyping techniques to explore generative ideation in the front-end of the design process requires us to not only look beyond the tangible, but beyond the designer and traditional applications of design to include a more diverse audience. This begins with the designer’s becoming more aware of the underlying power their skills and techniques have to engage people on matters of concern, as well as matters of fact.
Chapter 3: Process and Methodology

“Designers bring multiple talents to the solutions of complex issues, but first and foremost in my mind is the incorporation of empathy, of incorporating the needs of the people who must work within the system, the people who must approve it, and the people who are to benefit from the resulting system.” – Don Norman

3.1: Research through Co-design

To understand, first-hand, the roles of the different stakeholders and the designer in the co-design process, I conducted a research through co-design case study with Physics Education Research at The Ohio State University to explore the ideal student learning experience.

By focusing on the process, roles and artifacts prototyped throughout the study I aimed to gain a greater understanding of how different prototyping techniques can be used in the co-design process to support stakeholder collaboration, ideation and communication. This type of research approach is referred to as Research Through Design (RTD) “Researchers make prototypes, products and models to codify their own understanding of a particular situation and to provide a concrete framing of the problem and a description of a proposed, preferred state… Designers focus on the creation of artifacts through a process of disciplined imagination, because artifacts they make both reveal and become embodiments of possible futures” (Zimmerman & Forlizzi, 2007)
thesis is a unique application of RTD as the focus is not just on the artifacts and designer, but also on the roles of the co-designers.

This approach enabled me to bring together different stakeholders around a common, localized problem and involve them in an iterative series of interviews and co-design workshops and meetings. During these sessions, stakeholders actively engaged in prototyping new experiences and developing concepts to understand and improve the freshman student learning experience in Introductory Physics 101.

3.2: Overview of Process

I chose to involve the Physics Education Research stakeholders as co-designers in order to benefit from their collective knowledge and unique perspectives on the subject. The faculty and staff stakeholders were all closely associated with the freshman courses and had started to talk about the need for change at that level. Engaging them as collaborators in the early stages of the design process, I hoped, would enrich and inform the generative design process (Steen, 2011). Involving them over a series of interviews and workshops would help to engage them as co-creators in the entire process, and not just as fleeting participants in the study.

The process methodology was considered and designed in a way that would support this collaboration and engage the stakeholders as co-designers of the ideal learning experience. I anticipated that the focus of the project would remain within Intro Physics, and that the ideas or experience created would directly benefit the stakeholders’ understanding of what a shared ideal experience would be. An iterative approach was taken to allow the ideas generated to organically develop and grow over time (see Figure
2). This process of co-design also seemed relevant to apply to an educational setting as there is a growing community within the learning sciences that has begun to look at participatory design from a learning perspective, not just a designerly one. The field of learning sciences seeks to understand learning so it can be made more effective. "In exploring participatory design through a learning lens, it comes to light that all of the stakeholders are partners in a learning process, which creates shared understanding and collaboratively constructs new knowledge." (DiSalvo, 2016) DiSalvo draws a link between successful participatory design activities and the theories of learning sciences as a way to improve participatory design methods.

3.3: Prototyping Methods

I explored eight different prototyping methods across the co-design process. The three introduced into the first phase were Prototype Seeds, Vision Maps and Rough Storyboards. In the second phase of the process Journey Maps, Refined Storyboards, Scenario Video, and both Paper and Digital Interface Prototypes were used to communicate the outcomes to internal and external audiences.

3.3.1: Prototype Seeds

Prototype Seeds are ideas generated by the designer in the interview phase of the process that took the form of concept statements supported by sketches. These Seeds would then be introduced when the stakeholders were asked to prototype a Vision Map of an ideal learning experience.
Figure 2: The process diagram of phase one in the co-design process.
3.3.2: Vision Maps

The Vision Map was the main co-design activity in the first two workshops and challenged the separate stakeholder groups to imagine and build their visions of an ideal student learning experience. The process and materials presented for the stakeholders to prototype with were chosen after a series of pilot tests and iterations. The objects were simple 3D blocks, connectors and, importantly, 3D people. The canvas was a large tabletop covered in brown paper that the co-designers could also write on. Prototype Seeds were introduced along with the materials before the Vision Map was built.

3.3.3: Rough Storyboards

Rough Storyboarding was the prototyping activity in the final workshop session that enabled the co-designers to select an idea generated in the first two workshops, and imagine in more detail what that student experience would be. The groups created their storyboards, presented to each other, then a vote was taken on which concept to develop further.

3.3.4: Journey Maps

Designer-made journey maps were a higher-fidelity prototype that could convey the ideal experience that was envisioned through the vision mapping. This map would act as a ‘high-level’ summary of the ideal learning experience for Intro Physics students.
3.3.5: Refined Storyboards/ Scenario Video

I took their simple storyboard, along with the audio of their discussion, to inform and inspire a higher-fidelity storyboard that would eventually inform a high fidelity, live-action scenario video.

3.3.6: Paper/Digital Interface Prototypes

Over several months, I met one-on-one with the different stakeholders to share with them the refined storyboards that I had developed to convey the student experience. Then together using the storyboard and paper phone templates we together created the interface that would govern the user experience. The resulting paper prototype was then translated into a digital ‘click-through’ prototype.

3.4: Initial Engagement and Planning

The following sections break down each step that was taken during the process and explain the aim, plan, execution and outcome of each phase. Understanding how each phase influenced or inspired the next is also addressed.

3.4.1: Initial Discussions - Identifying Scope & Stakeholders

The process began with initial discussions with my Physics contact Professor Dr. Andrew Heckler, a professor passionate about improving student understanding and experience.

Our meetings helped shape the purpose and established the scope of the collaboration. As collaborators, we both had expectations on what the outcome should be
and this informed questions that we both hoped to explore during the proposed interviews and workshops. Dr. Heckler’s questions asked: What is the ideal student experience of Introductory Physics? How can that be supported? While my own research questions focused on the mechanisms of the research: How can prototyping engage non-designers to imagine future experiences? How can the stakeholders play an active role in the co-design process? Our questions differed as we were approaching the study from different perspectives. My questions were centered around the methods and processes that would structure the collaboration and eventual outcomes, while Dr. Heckler’s questions focused on improving the student experience of Intro Physics.

In continued discussions with Dr. Heckler, we determined a list of ideal stakeholders that included: faculty, instructors, course creators, support staff, teaching assistants and students associated with the Physics course (see figure 3). For the initial phase of the process, we selected a small group of ten participants representing the roles identified above. This allowed me to build relationships with a carefully selected cross-section of stakeholders to gain a unique perception of their concerns and possibilities. After identifying the different stakeholders, I contacted them individually to arrange an introductory meeting and interview time.
3.4.2: Interview: Questions & Card Sort

I began by using interviewing as a method to understand individual perspectives. I interviewed stakeholders before the first group workshop as I hoped that this would allow them to be more open with their opinions. I also saw this as an opportunity to start building a relationship with the stakeholders, gather insights that could be applied to the preparation of the workshop activities and gain inspiration. (Schultze, 2011) This inspiration would later be used to inform ‘Prototype Seeds’ that were introduced to the stakeholders at the workshops.

I prepared a list of 12 questions and built a card sort deck of 68 education-related images and icons to inspire, stimulate and provoke future-focused discussions with the interviewees about ideal and avoidable futures for Physics Education (Davis, 2009) [included in Appendix B]. Before putting the final deck of cards together, I compiled a
bank of images related to education (see Figure 4). This bank was then iteratively reduced until a manageable set of cards was present.

![Figure 4: The selection process of the images and icons involved pinning all the options up on a wall and curating them to ensure there was a range of different images.](image)

I initially interviewed eight stakeholders. When arranging to meet with the stakeholders it was important to meet in a place they felt comfortable (Sanders & Stappers, 2012). Due to this, most of the interviews took place in the Physics Research Education building. Each interview lasted 45-60 minutes. Before the interview began, stakeholders signed a consent form as part of my IRB-approved protocol. I then introduced the purpose of the interview, asked a series of questions [included in Appendix A] about the current learning experience and finished with the card sorting activity that shifted the discussion towards an ideal experience in the future. The
stakeholders were instructed to sort the cards into two groups, a five-card positive future and a three-card negative future (see Figure 5). They then talked about the cards they had chosen and what they meant to them, in relation to the future of Introductory Physics. All the interviews were audio recorded and the card sort results were photographed and documented after I completed each interview. I also took extensive notes during each interview that I used to build my understanding of the different perspectives and to inform the planning of the group workshops.

Figure 5: Graduate Instructor stakeholder sorting through the card deck for images that represent positive and negative futures for Introductory Physics during interview stage.

After interviewing all the stakeholders, I also created a visual comparative of the results of the card sorting activity to share with everyone at the first workshops. The larger the image, the more times it was selected by different stakeholders during the
interviews. The numbers in the lower-right corners indicate how many times it was selected (see Figure 6). It was my hope that these images would spark conversation and discussion about an ideal future before the group started to prototype that experience. It also acted as inspiration for me. I pinned up the results above my desk as I began to generate ideas and materials for the group workshops. These visual stimuli reminded me of what was important to the Physics stakeholders in the future [full results included in Appendix B].

![Image of positive future images chosen by the eight stakeholders.](image)

Fig 6: Positive future images chosen by the eight stakeholders.

As I interviewed different stakeholders, I began to understand the course from the different perspectives. This gave me a unique understanding of the current system as
whole and personal aspirations for the future of the course. The current course structure was thought of as outdated by most of the faculty and staff. The six contact hours of lecture, lab and recitation had become disjointed and no longer connected to each other. This was seen as a big disadvantage to providing students with a coherent experience.

Most of the faculty also seemed to be aware that the textbook homework assignments answers could be easily found on Yahoo Answers. From a student perspective, the lectures were not helpful. Students valued time spent meeting with teaching assistants during office hours, recitation or problem solving with friends as the most important to aid their understanding. More than anything, the students viewed the course as a requirement, i.e., something they had to do in order to be accepted into their engineering or science major.

All of the faculty and staff conversations brought up the logistics of the course and that it would take a lot of time and energy to redesign the current system. Every semester, roughly 1500 students take Introductory Physics.

The stakeholders spoke of their hopes for the future of the Intro Physics course. Themes such as improving student community and collaboration, avoiding content overload, better understanding of concepts instead of question answering, and better integration of the lecture, lab and recitation formats were shared by several faculty and students.

At this stage of the process, as the designer, I was starting to identify shared concerns amongst the stakeholders, but also the areas for which they differed. Part of my thought process was to categorize the concerns based on the scale and scope of the issue or idea. After that I would start to generate small ideas that I thought could address one of
the issues raised to improve the student learning experience. Identifying overlap between
the students, faculty and staff perspectives allowed me to generate concepts that I thought
could address all three (or more than one). These initial conversations and insights would
feed the prototype seeds that I would introduce to the stakeholders at the workshop.

**3.4.3: Prototyping Workshop Setup**

A workshop format was initiated after the interviews were completed in order to
bring the different perspectives together first to create and share their ideal student
learning experiences by stakeholder group for Introductory Physics 101, and then
together to create a shared ideal vision. This was achieved over the course of three
workshops. In the first two workshops, stakeholders were separated into a student group
and a faculty, teaching assistant and staff group. This was done in order to let the
stakeholder groups speak openly about their current and ideal experiences before
bringing everyone together. The third, and final, workshop brought the two groups
together to create a shared vision of the ideal student-centered, learning experience.

Each workshop explored the ideal learning experience from a different viewpoint.
Three viewpoints, survey, gaze and route (Tversky, 2004) were explored as a means of
collectively creating a new experience. The survey viewpoint is from a stationary
position above the environment. When thinking about the learning experience, this can be
interpreted as the process flow or system visualized by a map that determines the spatial
existence of landmarks and objects. The gaze viewpoint is from an unchanging viewpoint
looking onto an environment, like looking into a room from a doorway. This can reflect
the faculty and staff stakeholder perspectives and allows for expression of needs for a
future system. Finally, the route viewpoint is from the student perspective of traveling through the experience. In our system the route becomes the user experience that allows people to describe feelings and thoughts about the touch points.

The structure of the first Faculty and Student group workshops was the same. The process for stakeholders to express their ideal learning experience was inspired by a framework called “the path of expression” (Sanders and Stappers, 2012). This framework enables stakeholders to think about the future by first expressing ideas about past and current experiences in order to prime the conceptualization of future experiences. The path of expression serves as a “scaffold upon which to build the journey that participant will take in generative design session.” (Sanders and Stappers, 2012) There are four general steps to “path of expression” (see Figure 7):

1. Immerse in the current experiences
2. Connect backwards to past experiences through feelings and memories
3. Dream for future experiences
4. Generate and express new aspirations for ideal future experiences

The third workshop challenged the co-designers to consolidate their ideal futures, and focus in detail about how that experience would play out.
In all three workshops, the same research documentation process was followed. Audio was recorded for the entire workshop, video was filmed of the stakeholders making and presenting for each activity during the workshop and images were photographed to document the process and what the stakeholders created.

To support the planned collaboration between stakeholders in the final workshop, an informative summary video was created to explain the outcome of the first two workshops. This video was posted online for stakeholders to watch before attending. This acted as a priming tool in the process. A priming tool prepares participants for the activities planned in an upcoming workshop. The third workshop would begin with the stakeholders discussing the different outcomes of the first two workshops, therefore the summary video primed the participants by reminding them of what they had created and informing them on what was created in the other workshop. So the documentation output had a dual purpose; it allowed me to analyze and reflect upon the workshops, and also provided the footage for the summary video (see Figure 8).
Figure 8: A total of 8 interviews and 3 workshops were conducted in the generative stage

3.5: Workshop 1 & 2 Process Overview

The stakeholders were divided in two separate workshop groups: faculty and staff, and students. The workshops were held on separate days. Both workshops lasted two hours. Five stakeholders attended the faculty and staff workshop, while three freshman students attended the student workshop. The purpose of the first two workshops was to understand the different perspectives as they related to the current learning experience before the co-designers prototyped the ideal student learning experience using the Vision Map materials. The card sort results informed and inspired the Prototype Seeds that were introduced in the Vision Mapping activity. The outcome of both workshops was a vision of the ideal student experience that was taken into the third workshop when all the stakeholders were brought together.
3.5.1: Workshops 1 & 2: Current & Past Experience Collage

After brief introductions and a run through of the agenda for the workshop, the stakeholders individually completed a collage of their current perception of the student learning experience (see Figure 9). They did this using cutout shapes and word stickers [included in Appendix C]. Once all the stakeholders had finished creating their representations, each presented what they had created and what it meant to them (see Figure 10).

Figure 9: Faculty & Staff creating expressions of their current learning experience
3.5.2: Workshops 1 & 2: Card Sort Results

After completing the current experience collaging activity, stakeholders were introduced to the outcome of the previous card sort activity (see Figure 11). This fueled an open discussion about the important attributes an ideal student learning experience should encompass before the stakeholders were asked to prototype that experience in the final activity.
3.5.3: Workshop 1 & 2: Vision Mapping

Stakeholders then used a set of physical building materials to collectively prototype a vision of the ideal student learning experience [included in Appendix E]. The physical building materials included: people figures, various blocks, connectors, post-it notes and pens (see Figure 12).
3.5.4: Workshop 1 & 2: Vision Mapping Pilot Test

The Vision Mapping materials were selected based on feedback from 50 participants in two separate workshops that piloted a larger set of different building materials. The pilot participants created on a surface that was covered in brown paper and they were encouraged to annotate their creations. There were, in total, ten participant groups, each with five members. The groups created a range of models using the materials that represented both elements of personal experience and system considerations. The materials that were selected based on this pilot provided a range of ambiguous shapes that were playful and could be used to create a multitude of formations when considering systems or experience.
3.5.5: Workshop 1 & 2: Prototype Seeds

While conducting the interviews, small ideas (i.e., seeds) started coming to mind as I learned more about the stakeholders’ needs and perspectives. These seeds were generated directly from the interviews and through my own reflections as I started to build a better sense of the current (and preferred) learning experiences. All of the prototype seed cards were created and produced by me, the designer, but the inspiration and influence came from interviews, secondary research and/or directly from the stakeholders as shown by the colour-coded dots. The prototype seeds included: a pop-up study group app, live stream problem solving platform, structured study group app, instant student bulletin board, gamification of exercises, interactive classroom installations and virtual office hours. (see Figure 13).

Figure 13: The seven Prototype Seeds generated during the interview process.
I wanted to share these ideas at the workshops, but did not want to present them as answers or solutions but as small ideas that stakeholders could choose to accept or reject as part of their envisioned future. Prototype seeds were a means to introduce these concepts through visual and textual concept boards [included in Appendix D].

The prototype seeds took two forms for the workshop, an 11x17” poster version that was displayed on the wall next to where the participants were prototyping the ideal learning experience (see Figure 14), and a smaller ‘baseball card’ sized version that the stakeholders could place in the environment that they ultimately created to signify how and where the seed would be incorporated, if chosen.

*Figure 14: Introducing the Prototype Seeds to stakeholders.*
After sharing the results of the card sort activity in the workshop, I explained that for the final activity, the participants would prototype an ideal student experience using the materials provided. I then introduced each Prototype Seed briefly and explained how the stakeholders could use the baseball-styled cards to incorporate a seed into the ‘vision map’ that they were about to create to represent an ideal learning experience.

In both workshops, participants were guided to generate new ideas for an ideal student experience and to incorporate one or more seeds into their vision only if they thought it would be beneficial. Not using any of these seeding prototypes was also suggested as an option. Both groups were (very) comfortable rejecting seeds that they didn’t think were relevant. I considered this a positive as it meant that the ideas had been presented in a way that they didn’t seem too valuable to ‘trash’. I could have built physical mock-ups of the concepts and introduced them to the stakeholders instead. I make the decision not to do this as I did not want the seeds to take center stage in the minds of the co-designers while they created an ideal future. Presenting the seeds as ideas, not as physical mock-ups was important to striking a balance between inspiration and direction. The seeds certainly helped both groups apply technological ideas to their vision that otherwise may not have featured in their visions.
3.6: Workshop 1 - Faculty & Staff: Outcome Overview

The faculty and staff stakeholders intentionally created their ideal learning experience vision first, then added seeds that they thought could support that vision (see Figure 15). Their vision was a hands-on, collaborative studio styled classroom that would successfully combine lecture, recitation and lab to deliver an engaging learning experience for students (see Figures 16 and 17).

The faculty and staff stakeholders adopted the scaled-up classroom format of small groups of students working together in a large, open plan classroom space instead of a lecture hall. The classroom would also have interactive stations where students could...
complete manipulative, hands-on tasks. These groups would be supported by a structured study application that students would use on their phones. The application could assign groups for that day or week, provide a menu of class tasks to complete, provide feedback and facilitate class activities such as ‘scratch-off’ quizzes, a quiz format to promote healthy competition amongst the class by rewarding points to ‘scratching-off’ the correct answer first time. Textbook homework was supplemented by peer-reviewed writing and small, project-based homework assignments that would encourage group activities.

Figure 16: The faculty and staff vision map outcome.
The faculty built their ideal learning environment first, and then added the seeds as a way to facilitate or heighten the proposed student experience. The structured group study app (seed #3) was used as a central component in the classroom, while gamification (seed #5) and interactive tech (seed #6) in the classroom were used as add-ons.

**3.7: Workshop 2 - Student: Outcome Overview**

Students were given the same activities, instructions and materials in a second workshop. The student group imagined the campus landscape and how students could be better connected to their peers and instructors (see Figures 18 and 19). The student workshop process followed a similar path to the faculty one, although they incorporated the seeds into the vision map at a much earlier stage, meaning that their final outcome
was more centered around the seeds selected. The student group even combined seeds to create a hybrid concept. Two seeds were combined first, bulletin board (seed #4) and GPS app (seed #1), to create a means for students to self organize and study together in groups. Interactive tech (seed #6) was also used in class to support TA office hours and virtually connect the students not in attendance.

*Figure 18: The student vision map outcome.*
Figure 19: An annotated vision map prototyped by the student group

After the activity was complete, the students helped inform personas that would be used in the final workshop by coming up with different student and faculty characters that could be connected to the physics course. These personas would be used as part of the storyboarding activity. This was not part of the original research plan. I took this as an opportunity for the students to inform the personas.

3.8: Stakeholder Group Workshop Comparison

Having abstract objects to prototype an intangible subject such as student (user) experience enabled the participants to give shape to their ideas without prescribing the outcome. Both groups prototyped experience through creating environments that acted as a stage for the experience to be played out in.
The faculty created a detailed ideal classroom experience, but struggled to imagine beyond the classroom. The students prototyped the ideal landscape to learn in and imagined a virtual network that could connect students and faculty offline. Offering the prototype seeds as ‘ideas’ was important to establish that they should not be central to the vision. The faculty group chose to create their world first, then introduced the seeds that they thought were beneficial. The students used the seeds in the creation of their world. Some of these seeds grew to become central elements in the experience, whereas others were viewed as add-ons or extras.

3.9: Summary Video

To prepare the stakeholder groups for the final workshop, where they would come together to discuss and consolidate ideas generated individually, an eight-minute summary video was prepared and privately posted on Vimeo (see Figure 20). This video summarized the main ideas to come out of both sessions and posed questions for the stakeholders to consider before attending the third workshop.

The video first summarized the different issues that were raised during the interview process and current experience collaging activity. It then focused on the outcome of the two vision maps created and the ideas that were embedded in them. The video ended with questions that the stakeholders should think about before they attended the next workshop.
The process of making the summary video unexpectedly helped to clarify what was important to take from the two workshops into the final session. The challenge of scripting a summary that could fit into a reasonably short video format, but still effectively convey the ideas forced me to really consider what was important to the stakeholders as I analyzed the output of their separate sessions. Working through several iterations of the script and multiple versions of the final narration and visuals honed the video to focus on what was most important. In both sessions a fellow design graduate student assisted with documentation for the video. This was great as I had lots of footage and images to pull from. But it also meant more time was needed when prepping my
assistants on what shots I was looking for and the logistics of having multiple cameras, video recorders and audio recorders in the room.

3.10: Workshop 3 Process

For the final workshop, faculty, staff and students came together first to discuss the vision maps created in the previous two workshops and next to storyboard a specific experience from the visions generated. It was important that by the end of the workshop, we would have a clear direction on what part of the proposed student experience would be developed further beyond the initial workshops. The session started out with introductions, then a round table discussion about the different maps that had been created. Faculty and students found commonalities and chose their favorite elements from each map. The group was then divided into two mixed-stakeholder teams and facilitated to create an experience storyboard of their chosen part of the combined vision. The workshop ended with each team presenting to the other and reflecting on the experience of being involved in the co-design process.

3.10.1: Workshop 3: Consolidation Discussion

The workshop started with a round table discussion about the two vision maps created in faculty and student workshops (see Figure 21). The maps were pinned up on the wall with the main ideas listed beside them to help stimulate discussion. The prototype seeds that were incorporated into the different maps were also pinned up. As the group discussed their favorite concepts from the maps, I noted which concepts were met with the most interest and placed them in between the two vision maps (see Figure 22). After a
lengthy discussion, the group selected two concepts that they wanted to focus on in more
detail in the storyboarding activity.

*Figure 21: In workshop three, stakeholders discussed the different vision maps created.*
Figure 22: Faculty (left) and student (right) maps were displayed during the workshop and concepts they were most interested in were placed in the middle.

**3.10.2: Workshop 3: Storyboarding Experience**

Once the group had determined two ideas to storyboard, they were divided into mixed stakeholder groups and asked to storyboard the student experience of one of the ideas (see Figure 23). Both groups were provided with written instructions, blank storyboard frames, pens and personas that they had to incorporate into the story they would create [included in Appendix F]. The personas were fictional students that represented the different typical students in Intro Physics. They were communicated through baseball styled cards with personal information about the different characters that included their name, age, study habits and a quote that gave the stakeholders a sense of what type of relationship the student had with Intro Physics.
Figure 23: One of the mixed stakeholder groups is introduced to the storyboarding activity.

To support the storyboarding activity, a tabletop poster with ‘in class’, ‘outside class’ and ‘virtual’ acted as a reminder that the storyboard had to consider all three areas (see Figure 24).
For mixed stakeholder group A, the outcome was a context of use scenario for a GPS enabled application that would allow students studying the same subject to form local study groups and receive virtual support from instructors and teaching assistants (see Figure 25). For stakeholder group B, the outcome was an in-class application that would support and facilitate group activities and provide feedback to the student groups and faculty (see Figure 26). Once the two teams had presented and discussed the different ideas, the group decided that the GPS enabled group study application would be taken forward in the design process.

Figure 24: The tabletop poster for the storyboarding activity
Figure 25: The storyboard produced by a mixed stakeholder group A.
During the storyboard activity the stakeholders struggled to visualize their rich discussion surrounding what the student experience would be. Their output was simple stick figure drawings (see Figure 27). In the previous workshop, the stakeholders were manipulating materials that had already been designed and prepared for them. However, in this storyboarding activity, only blank cells were provided. Perhaps a blank canvas proved to be too much of a creative leap for the stakeholders to make. As I listened to their conversation on what the proposed experience should be, I could imagine the composition of the cells for the storyboard, but the stakeholders found it difficult. In that moment I recognized the role of the designer becomes more important as you move
through the co-design process. The stakeholders had great ideas; they just couldn’t convey them visually. Being part of the workshop and having the artifact storyboard to use as inspiration, I would later create a more complete storyboard.

![Figure 27: A stakeholder sketching out a storyboard cell.](image)

### 3.11: Initial Research Summary Video

The second summary video focused on the entire co-design process that the stakeholders had taken part in and the final outcomes of that process. This gave them an understanding of where we were in the design process, and that there was still the development phase to work towards. Similar to when I was creating the short video to convey the ideas that came out of the workshop, the experience of having to communicate the process through a linear narrative provided a surprising amount of clarity to the process. Taking a six-month, intensive process and condensing it down to
seven minutes challenged me to focus on the important aspects of my process, and how each stage of the process affected the next.

3.12: Prototyping to Communicate, Learn and Develop

At this stage in the process the initial generative workshops were completed and the stakeholders and I moved into the development phase of the process. I really felt the gears shift as my role as the designer creating prototypes to give form to the ideas became more central to the co-design process. Earlier in the process I had designed and created the instructions, questions and materials in order to structure the workshop discussions. However, the role that I took on at this next stage was more familiar to me as someone who worked in Product Design. The challenge was to continue to involve the stakeholders in a meaningful way so that they could be active voices in the design development. The roles of the stakeholders changed throughout the process too as they became more interested and invested in the ideas that they had helped to create.

To convey the ideas that were generated in the workshop, and communicate the application concept, I decided to iteratively co-design three outcomes for the development phase (see Figure 28). A scenario video that would depict the normative path of a group of students using the application. A click-through prototype of the interface that would convey the functionality and usability of the application. And finally, a user experience journey map that would show where the application concept lived within the larger ideal experience that was prototyped during the three workshops.
Figure 28: Process diagram of the second phase of the co-design project.
3.12.1: Prototyping an Engaging Experience Narrative

Using the GPS enabled group study application as the focus for development, I took the rough storyboard that was generated by the mixed stakeholder group and created a more detailed scenario. It was my intention that this storyboard would be used to inform the scenario video. However, the storyboard also became an important co-design tool when prototyping the proposed experience and the interface interaction with the stakeholders.

3.12.2: Scenario Video: Developing Stakeholder-made Storyboards

During the third workshop while creating their rough storyboards, the mixed stakeholder conversations about the proposed experience were rich in details. However, this wasn’t reflected in the storyboard outcomes. There was a gap between the experience they were discussing, and experience depicted on the storyboards. Therefore, the first stage in the development process was to create a refined storyboard that captured their discussion but also conveyed a believable narrative.
This meant creating a new storyboard that was informed by their discussion as well as the rough storyboard outcome (see Figure 29). The first draft of the script for the refined storyboard introduced elements such as narrative structure, persona characters and locations that created a more cohesive and believable experience. The narrative structure set up the current experience, then introduced an unexpected element (the group study application) and finally showed the transformation into the new experience. Persona characters, their actions and behaviors were further informed by interviews with student, faculty and graduate stakeholders. All of this was placed into a standard storyboarding format that included information about location, characters, descriptive actions and a supporting sketched image for each scene [included in Appendix E].

Figure 29: Early storyboard sketched out after the final workshop.
For the refined storyboard, I decided to focus on the normative path that a group of students would experience when using the application. The normative path is the most commonly followed series of actions taken while using the application. This was important as it defined the scope of the concept that the scenario video and app interface would communicate. This approach was informed by lean and agile development that focuses on quickly learning through iteration (Ries, 2015). The narrative focused on how students would find each other, create a group, meet up and receive virtual support from an instructor. Other features or experiences would be considered fringe cases that could be addressed once the main functionality of the prototype was successfully realized.

After revising the written storyboard draft, I introduced visuals to support the descriptive text (see Figure 30). These visuals were hand-sketched stills that allow me to think about the different shots I wanted in the scenario video, but also gave the stakeholders more contexts when I introduced them to the new storyboard.

Figure 30: Two cells from the refined storyboard.
3.12.3: Scenario Video: Filming the Scenario Video

Developing the interface prototype enabled me to drill down to the details on how the proposed application would work. In order to effectively communicate the student user experience I decided to create a short, live-action scenario video (see Figure 31). The video would act as an experience prototype to better communicate the interactions between the students. The video would also be presented in a survey to freshman science students to access the concept. Centering the concept development around the interactions that the faculty and students wanted to see instead only focusing on the interface design meant that creating the video enabled me to gain another perspective on how the app might work.

Figure 31: A still from the user experience scenario video
I worked with two experienced undergraduate photographers from Design to help with the filming, three Theatre undergraduates to play the parts outlined in the storyboard and eight voluntary extras from the Design Department. The locations for filming were determined by the film crew and a schedule drawn up for filming. We filmed all the scenes in the space of four hours on a cold and windy Monday morning. A series of versions were edited until the final video was uploaded as part of a survey that 201 freshman science students from Physics and Chemistry completed.

The storyboard that I had produced was a great asset to making the filming a success. The storyboard was used to help recruit actors, convey my ideas to my technical directors and to guide everyone during the filming session. However, there was still openness to certain parts of the storyboard that allowed my technical directors to suggest additional shots and alternative angles. I provided directions for the actors, but they also added their own ideas and suggestions. I feel these contributions from the different people involved in the filming really helped to bring the scenario to life.

3.12.4: App Interface: Early Paper Prototype of Interface

After creating the storyboard I wanted to mock-up the key elements of the application as a starting point to share with the co-designers. I did not want to communicate the interface in a digital format and chose to work with paper. My reasoning behind this decision was that paper would be faster and more accessible to the co-designers than moving straight into digital prototyping (Snyder, 2003). This would enable them to actively contribute to the prototype, as opposed to only providing feedback on usability. The focus at this stage of the development process was on how the
application would function; so simple line drawings were used to convey the functionality of each step in the process. The paper interface screens were numbered to communicate at what point in the story the interface was to be used. The focus of all the discussion was more about the experience of use, as opposed to what the interface would look like. In this regard, the paper screens acted as a means to frame and facilitate the discussion along with the storyboard.

3.12.5: App Interface: Storyboards to Develop the Paper Interface

I wanted the co-designer to engage with the proposed experience first, before drilling down into the interface design. This also gave the co-designer the opportunity to add to the storyboard, and raise questions about the overall student experience of what it would be like to use the application. The application co-design toolkit (see Figure 32) consisted of the proposed experience storyboard, interface sketches and materials to create/adapt the interface or storyboard (e.g., pens, paper, glue, scissors, coloured stickers). I met with six stakeholders, four returning from the previous co-design workshops and two new stakeholders from the sciences (a Chemistry Professor and another Freshman Physics student), to share with them the storyboard of the proposed experience and prototype how the app would work. I met with each stakeholder one-on-one. The interface prototype and storyboard changed after each session based on input from the stakeholders. The outcome from each one-on-one session was taken forward to the next. This iterative approach enabled all of the co-designers to contribute to the concept as it evolved over time [included in Appendix H].
During the sessions, the storyboard was introduced to the co-designers before the interface sketches were revealed. The response to the storyboard was positive from all the co-designers. Many of them were impressed with the believability of the narrative. The student co-designers, especially, related to the main character Jamie studying in her dorm room late on a Sunday night and in need of help to solve the problem she was stuck on.

After discussing the experience storyboard I introduced the paper interface screens to the co-designers. We then went back through the storyboard, relating the screens to the different points in the story. I encouraged all the co-designers to alter or add to the screens if they felt that something was missing, or if the interface could be improved.
The difference between what was contributed by the student and faculty co-designers was a point of interest. The faculty and staff co-designers were more concerned about higher-level considerations such as student safety, integration of the app into the current online system and delivery methods to make the students aware of the application. I would describe all the student co-designers as digital natives, meaning that they were very familiar with a variety of applications and online platforms and referenced them when adding features or screens to the interface prototype. They focused on both the high level concerns as well as interface details like how a student-user would control their privacy settings, how to avoid potentially awkward moments (such as someone’s request being
rejected by a group) and the finer details of the experience such as the introduction of push notifications and permission requests.

The low fidelity of the paper prototypes was successful in allowing the co-designers to actively engage in the creation process. The paper prototype screens were initially three to a letter-sized page. However, it became necessary to separate the sketched screens and lay them out on the table in order to allow the co-designers to add, remove or swap the position of the different feature and functions (see Figure 34). Of all the additional elements successfully added by the co-designers, only one of the interactions can be considered innovative. This can be attributed to the co-designers’ relying on their preexisting knowledge of currently available applications and their functionality/interactivity. Creating unique interactions requires a more complete knowledge of interaction design and what might be possible in the near future. As the level of detail and professional knowledge required increases, the designer needs to take a more central, creative role in the co-design process. The innovative interaction was a slide-into-view whiteboard feature that was added to the instructor support video call function by the graduate teaching assistant co-designer.
After meeting with the various co-designers and incorporating their input, I took all of the screens developed and created another paper prototype. This prototype’s purpose was to act as usability prompt before committing to a digital wireframe. I met with three freshman students not involved in previous rounds of development to test the functionality and logic of the application. I presented the new prototype one screen at a time, asking the participants to navigate through the application. Before I revealed the next screen I asked the participants what they expected to see based on what they had just selected. The participants were successfully able to navigate the application and complete the required tasks. Some additional features were added to the application based on this round of testing. For example, when selecting the ‘meet up’ option all three of the
participants expected to see a list view instead of a map showing their location and nearby study groups. Adding the ability to toggle between a map view and a list was introduced. This quick test highlighted the logic blind spots in the information architecture and informed the digital wireframing and interactive click-through prototype to follow.

3.12.6: App Interface: Wireframing interface and Interactive Click-through

As most of the design decisions had been made during the paper prototyping phase, creating the first digital wireframe and click-through prototype was accomplished quickly. The digital screens were made using a combination of standard component parts found online and assets created in Adobe Illustrator [included in Appendix I]. These screens were then imported into Flinto, a web-based click-through platform that allows you to link touch points on the screen to other screens, creating the illusion of a functional application. The advantages of using this type of software is that the prototype can be built quickly and screens replaced or improved by dropping new screens into the deck (see Figure 35). The downside is that the interactive capabilities are limited to standard animations. Moreover, as the application relied on GPS to function, a certain amount of role play was still needed when presenting it to stakeholders/new users.
3.12.7: App Interface: Click Through Prototype vs. Paper Engagement

How stakeholders and participants engaged with the digital versus the earlier paper prototype was interesting to observe. During the paper prototype phase the stakeholders were willing to question the interactions between student users of the application and edit, add or remove screens. But when presented with the click-through prototype, people’s responses became more evaluative. (Bellucci, 2015; Seok, 2014)

3.12.8: Journey Map: Proposed Student Experience

As I continued to develop the interface and scenario video I was concerned that the application concept would be perceived as the only outcome from the co-design workshops that the stakeholders participated in. I wanted to visually convey the multitude of ideas that the co-designers generated in a way that would provide an explanation to the future student experience that was prototyped. I decided to create two journey maps where the current and future could be compared to convey the new student experience imagined in the workshop sessions.
I started working with pen and paper to sketch out different options for the map (see Figure 36). I tried to think about where the stakeholders and major touch points would occur in the student journey in a given week. The current experience map was important, as it would give outside observers a sense of what the current state of the Intro Physics student experience is, before introducing the proposed new experience. It was also beneficial for the internal stakeholders, as they had not seen any visual comparison of the outcomes of the workshops. Interview recordings and current experience collage discussions informed the first iteration.

The future map was informed by the vision maps and resulting discussions across all three workshops. I worked with my peers and mentors as I iterated through several versions, moving from paper to digital journey maps (see Figure 37). During this process
I would meet with my stakeholders in order to confirm that the maps were, indeed, visually depicting the current and future experiences. The faculty stakeholders became more involved to ensure that the details at each point called out on the final map (see Figure 38) were accurate.

Figure 37: A more refined version of the student journey map.
Figure 38: The final journey map that conveys the future student experience.
3.13: Survey to Validate Beliefs and Concepts

The final part of the co-design process was to validate the assumptions made about the current student learning experience and validate the GPS-enabled group study concept. A survey was sent out by Dr. Andrew Heckler and Dr. Matthew Stoltzfus and completed by 201 freshman science students. A full executive summary of the report can be found in Appendix J. However, two of the bigger findings in relation to the co-design were that we were able to confirm our assumption that a large percentage of freshman science students study alone (see Figure 39) and that when presented with the scenario video as part of the survey, 92% of those student respondents responded positively to the concept (see Figure 40).

![Pie chart results from the question - Who do you typically study with?](image)

*Fig 39: Pie chart results from the question - Who do you typically study with?*
Figure 40: Results from the question - Do you think an application like this would be useful for freshman students?
Chapter 4: Discussion and Reflection

“We do not learn from experience... we learn from reflecting on experience.”

– John Dewey

4.1: Introduction

In this chapter I will now discuss and reflect upon my first-hand experience of successfully going through the co-design process with my stakeholders and implementing different forms of prototyping along the journey from the fuzzy front-end to the delivery of co-designed prototypes. These reflections will help to inform my conclusions and are supported by other recent designer and researcher findings that align with my own reflections and coincide with my own research objectives and questions. The chapter begins by reflecting on the first phase (see Figure 2) of the co-design process with a focus on the prototypes that were introduced by the designer, prototype seeds. Then it will discuss the prototypes co-created by the stakeholders: vision maps and rough storyboards. These are introduced in chronological order, with each reflection referring to my role as a designer, the roles of the co-designers or the roles of the prototypes. After that, the focus will be on the second phase (see Figure 28) in the process and will reflect on the iterative co-designing of the three design outcomes/artifacts: the student experience journey maps, user experience scenario video and application interface. These are introduced by scale, moving from a broad view in the journey maps, to the detailed
view in the application interface. This chapter will end with high-level reflections across
the process and about the roles of the designer, co-designers and prototypes. This will
lead into and inform my final conclusions.

Throughout the co-design process I gained so much from the first-hand
experience. However, I will only focus on the insights and understandings that are within
the scope of my research questions for this discussion and reflections chapter. To
reiterate, those questions were: What are the roles of the designer (and the co-designers)
in the co-design process? How can prototypes be used to generate new ideas and reflect
on the proposed experience? How can co-designers be supported to collectively prototype
an engaging experience that meets their future needs and goals? How can co-designers
remain as active voices as the design process moves into development?
Figure 41: The process diagram of phase one in the co-design process.
4.2: Co-design Workshop Reflection

Over the course of the three co-design workshops, three prototyping methods were tested to examine their impact. Designer produced prototype seeds were used as inspirational materials for the main co-designer prototyping workshops whose aim was to create the vision maps. Finally, rough storyboarding was used as a prototyping method for the co-designers to imagine and express a future experience in a granular manner as part of the final workshop session. The artifacts that these co-design activities generated then informed and inspired the development phase of the design process.

4.2.1: Seeds as Prototypes

Prototype seeds are ideas generated by me, the designer, in the interview phase of the process that took the form of concept statements supported by sketches. I created the prototype seeds as I started to gain a sense of the current and ideal learning experiences during the interview phase. These seeds were introduced when the stakeholders were asked to prototype a vision map of an ideal learning experience.

The stakeholder interviews provided me with not only information about the current experience from different perspectives, but also inspiration. In this project, I immersed myself in Introductory Physics; the people, the systems and the end-user experience i.e., student experience. Through this immersion I was gathering information, and actively searching for inspiration. “The classic depiction of the artist waiting for inspiration to strike like a lightning bolt is a myth. It’s not something you wait for. Inspiration is found by those who seek it out.” (Dolan, 2013)
As an undergraduate design student, I would use provocative imagery to inspire myself in order to generate form or function for new products. The process was almost entirely internal, based on how I alone interpreted the imagery and in what direction that sent my ideas and sketches. In the thesis process, however, it was predominantly external information that inspired ideas. This information came from stakeholders, implicitly and explicitly; describing unmet needs or pain points during interviews and from secondary sources such as educational, technological and social trends. Possible solutions that could improve the current student and/or faculty experience were generated when combined together. Ideas also came directly from the more creatively minded stakeholders at this stage. A third, more implicit, resource to select worthwhile concepts comes from my own design intuition on what merits a successful concept.

The seeds acted as a “medium that incorporated the implicit knowledge” (Schön, 1983) that I gained from the series of interviews conducted with the stakeholders about their hopes for the future student experience. To this degree, the prototype seeds “served as a moment of reflection for the designer” (Schön, 1983), me.

Offering the prototype seeds as ‘ideas’ when introduced at the workshops was important to establish that they did not have to be central to the vision and didn’t have to be incorporated at all. How such seeds are presented needs to be careful considered. The term ‘prototype’ is a powerful word that means so many things to different people and should be avoided (McKenzie, 2015). Terms such as ‘idea’ or ‘sketch’ are more suitable for describing seeds at this stage in the process.

During the ideal experience vision mapping, the prototype seeds were introduced and acted in a similar way as boundary (or framing) objects (Brandt, 2007; Doll, 2009).
They were informed by stakeholder interviews and reflected the concerns of each group. As these concerns were different, the seeds also represented the conflict between the groups and supported intergroup communication (Stoytcheva, 2015). An example of this would be the pop-up study group seed (seed #1) informed by student interviews versus the structured study group seed (seed #3) that was informed more so by faculty and instructor interviews. However, the seeds were only ever presented as sketches, not actual objects. It is more accurate to suggest that the seeds were weak boundary objects.

“Boundary objects might be weakly structured as to achieve flexibility and allowing transference and commonality, but strong enough to be used.” (Ehn, 2008)

The seeds also acted as a means to push the stakeholders towards more radical ideation during the iterative sessions. According to Verganti and Norman (2014), a human-centered approach of iterated observation, ideation, quick prototyping and testing is very well suited for incremental innovation but unlikely to lead to radical innovation (Norman and Draper, 1986).

Introducing speculative or provocative prototype seeds could potentially push stakeholders further into the future without prescribing the outcome. The prototype seeds that were developed for this project were grounded in the present/near future but could be re-conceptualized in future work to focus on the distant future.

4.2.2: Vision Maps as Prototypes

The vision map prototype was the main activity in the first two workshops and challenged the separate stakeholder groups to imagine and build their vision of an “idealized” (Ackoff, 2006) student learning experience. The process and materials
presented for the stakeholders to prototype with were chosen after a series of pilot tests and iterations. The objects included simple 3D blocks, connectors and, importantly, 3D people. The canvas was a large tabletop covered in brown paper that the co-designers could also write on. Prototype seeds were introduced along with the materials before the vision map was built. Before creating the vision map, stakeholders individually created and presented a representation of the current experience with paper shapes and word stickers on poster boards.

When asked to imagine the ideal student experience, the prototypes that the faculty and student co-designers created separately became environments, much like a stage, that the experience was acted out in. However, the scope of the two prototypes was very different. The faculty and staff prototyped the ideal classroom experience, while the student group prototyped the ideal experience from a campus-wide perspective. The combined visions of faculty and students created richer ideas than either in isolation, covering the experience that would take place both inside and outside of the classroom. Due to the differing scales, the faculty vision could be ‘dropped into’ the broader student version.

“Prototypes as manifestations can be seen as interactions on a more concrete level than other interactions such as discussions.” (Doll, 2008) Having abstract objects to prototype an abstract thought such as student experience enabled the stakeholders to give physical form to their ideas and become involved in the design process, without prescribing the outcome. This hands-on approach allowed the co-designers to engage in a more creative practice. “Most significant was the replacement of ‘system descriptions’
with engaging ‘hands-on’ mock-ups and prototypes that support creative skillful participation and performance in the design process.” (Ehn, 2008)

Furthermore, the act of prototyping with tangible materials enabled the stakeholders to discuss ideas while manipulating the idea in physical form. This helped to create a “shared mental model” (Neyer et al., 2008) of the future ideal student experience. The ability to physically represent ideas relating to the proposed system and experience helped to facilitate good communication that resulted in effective group work. “A prototype does not only stand for an important design technique but should moreover be regarded as a management tool that can be integrated into a structured dialogue between stakeholders.” (Rhinow, 2012) This, thereby, reduced the uncertainties and improved the confidence and bonding of the stakeholders (Doll, 2008).

4.2.3: Rough Storyboards as Prototypes

Rough storyboarding was the prototyping activity in the final workshop session that enabled the co-designers to select an idea generated from the first two workshops, and imagine in more detail what that student experience would be. The stakeholders were divided into two mixed stakeholder groups. Then, two ideas were chosen from the different ideas generated during the faculty and student vision maps. The groups created their storyboards, presented to each other, and then a vote was taken on which concept to develop further.

Discussion around the storyboarding was rich in details on how the student experience would take shape, however the storyboards that were created failed to effectively communicate the concepts to an external audience. This could be attributed to
two factors; not enough “scaffolding” was present to support the creative practice (Sanders, 2012) so the task of imagining a detailed experience was more difficult than the wider overview that was successfully completed in the earlier workshops through vision mapping. There is also the consideration that the storyboarding materials were not adequate since they were not as thoroughly pilot tested as the vision mapping materials, highlighting the importance of pilot testing. The vision map materials were pilot tested on 53 people, while the storyboard materials were pilot tested on 6 people. This highlights the importance of pilot testing if deploying or improvising through the co-design process. Interestingly, in both mixed stakeholder groups the youngest members of the teams became the designated drawers when making the storyboards.

The nature of the rough storyboarding activity was different compared with the earlier vision mapping activities also. The vision map materials have a toy-like quality and therefore a familiarity as everyone has used toys to tell stories and play out make-believe scenarios. However, the storyboarding activity requires a set of skills that are not second nature and require a certain level of professional knowledge or experience in order to successfully create the cells that make up a storyboard in order to convey the story being told.

Co-designers struggled to imagine the story from a first-person perspective. This was not an explicit instruction as I thought it would be natural for the perspective to be from the student experience. Imagining the experience from a first-person perspective is important as it focuses on the details. In both rough storyboards, a narrator speaking from a third-person perspective described the scenarios. Perhaps this was due to the very nature of storytelling with storyboards. The perspective is that of an observer or narrator
as opposed to other methods such as enactment or role-play that elicit first-person perspectives in a more natural fashion. A timeline that grounded the conversation within the context of a day, along with a character from whose perspective the stakeholders had to tell the story might have served as better tools to support a first-person perspective narrative.

Rhinow defines the three purposes of a prototype: to be a learning tool for design teams, a learning tool for users and a means to transfer knowledge to external partners of the team. (Rhinow, 2012) One could argue that the prototypes across the co-design sessions were successful as learning tools for the design and user teams (in this case the same team). However, they struggled to fulfill the third purpose. This meant I had to create summary videos that combined the prototype artifacts made during the workshops with audio and textual descriptions that allowed outside observers or future co-designers to understand the outcomes of the workshops.
Figure 42: The process diagram of the second phase of the co-design process.
4.3: Co-design Development Reflection

The ideas that had begun to take shape in the series of workshops were not fully formed concepts, which meant an iterative process was needed to define and develop the three deliverables. Before the second phase took place (see Figure 28), analysis and reflection on the outcome of the co-design sessions was undertaken. I did this through creating a summary video that acted as a form of analyzing the process and outcomes in order to share them with the Physics stakeholders but also with an external audience of my peers, mentors and the wider design community. Through the process of distilling the information, pulling out the main takeaways and ideas generated, and positioning them into a linear timeline, or story of events, I was able to draft a script that summarized the information, inspiration and ideas that came out of the workshops. Inadvertently, this process also acted as a means of analysis and reflection as it required me to revisit all the recorded audio, images and recordings to put together a cohesive outcome that could be understood by an external audience that was not involved in the process.

The following discussion and reflection is broken down into the three deliverables that were decided upon after this analysis; a journey map to communicate the proposed student experience, a live action scenario video to communicate the proposed mobile application and finally a click-through prototype that communicated the interface and interaction of the application.
4.3.1: Journey Maps as Prototypes

The Vision Map prototypes that the stakeholders co-created supported the communication of their ideas in a tangible form and conveyed the ideal experience between the stakeholders while also helping to build a ‘shared mental model’. However, the resulting models that were prototyped didn’t do a great job at conveying the ideas to an external audience beyond the workshop session. Therefore, I decided to create a high-fidelity prototype that could convey the current and ideal experience that was envisioned. This map would act as a ‘high-level’ summary of the ideal learning experience for Intro Physics students. Informed by guiding principles from User Journey Mapping (Schauer, 2013), my goal was to create a visual representation that could be easily understood and would convey the ideas that were present in the low-fidelity, stakeholder-made prototypes. During this process, I gained an unexpected understanding of my own process of synthesis and ideation through sketching and digital form manipulation using Adobe Illustrator.

After completing the workshops I spent time going through the data and ideas that were generated. The time spent analysing that data helped inform me on the overall experience that was being proposed by the stakeholders. I started the process of creating a journey map by sketching.

I used sketching with pen and paper to understand, synthesize, and make sense of what the ideal experience would look like in the form of a two-dimensional map. After initially sketching only the ideal experience, I decided it was necessary to first create a
journey map of the current experience, so viewers would be able to compare the current with the ideal.

When I was a furniture designer, sketching allowed me to imagine physical forms that didn't yet exist. I had a purpose, perhaps to create a structure to support a collection of books, and through the sketching process I was looking for a line, a form that appealed to me. There was also, however, the practical consideration of functionality. First and foremost, the structure had to store books. What I found aesthetically appealing while I sketched and modeled furniture was the result of my surroundings and culture that informed my ideals of elegance and beauty. My furniture was informed a lot by Scandinavian and Dutch design.

During the process of making the journey map, I used sketching to make sense of things that weren’t always physical. The journey map allowed me to communicate an overview of the touchpoints that the student would interact with. However, where does the influence come from? Maps? Charts? Schematics? The work of data visualizers and statisticians like David McCandless or Edward Tufte? I certainly used the same considerations of functionality and aesthetics that I applied to my furniture. The function remained that someone who wasn’t involved in the workshops should be able to understand what I was proposing simply by reading the map. The aesthetic considerations were important so the visual would be appealing, but in a similar manner to furniture design, the aesthetics could not reduce the functionality, or readability, of the journey map. Finding this balance became an exercise in consistency and reductionism. I wanted the viewer to see the connection between the current and the ideal, but also understand the changes that took place. Iterating provided more clarity, while getting feedback from
peers, mentors and stakeholders helped to identify the gaps, misconceptions and knowledge structures that are difficult to identify from one single perspective.

At some point the process of sketching became too restrictive. On reflection, the big advantage of using a digital pen tool like Illustrator is that I could quickly express, reflect and reorder my ideas. Working with Illustrator became more flexible, i.e., a system of nodes and lines that could be easily manipulated and reformed faster than on a sketch.

“Drawing helps us understand the situations as systems with nodes and their relationships. Movable [links and nodes] produce better systems models, because we iterate much more fluidly… This rapid iteration of expressing and then reflecting and analyzing is really the only way in which we get clarity. It's the essence of the design process. And systems theorists do tell us that the ease with which we can change a representation correlates to our willingness to improve the model.” (Wujec, 2013)

I repeated the act of making adjustments and presenting the map back to my cohort. Over time the focus became more granular on specific aspects of the knowledge structure. My Design cohort challenged me to create a more intuitive, visual journey, while the Physics cohort was able to provide feedback on the content that populated the map so it aligned with their vision from the workshops.

**4.3.2: Rough to Refined to Scenario Video**

During the final workshop, the two mixed stakeholder groups had created rough storyboards that could communicate the experience selected. The storyboards acted as good communicative tools for internal discussion and ideation, but failed to convey the concepts discussed to an external audience. Therefore, I took their rough storyboards,
along with the audio of their discussion, to inform and inspire a higher-fidelity, ‘refined’ storyboard that would eventually inform a live-action scenario video.

Directly after the final workshop, I sketched out the more complete storyboard of the chosen concept that the stakeholders were trying to detail in their rough storyboard. Translating the rough storyboard discussion into a quick sketch after the workshop helped me to capture the important moments. However, I had to go back through the audio of the discussion to inform the finer details of the script. I also had to take creative license to ‘fill-in-the-gaps’ and add richness to the student experience scenario. Details such as names, locations, scene changes and directions were required to create a fuller story. These details helped inform a script I wrote that would form the basis of the refined storyboards.

On reflection, I could have brought along designers to work with the mixed stakeholder groups to support the sketching phase of the storyboarding process. I would have done this myself, but the demands of facilitating and recording meant that I couldn’t sit down and work with a group. This is certainly a downside to having a designer in the room, but in the role of facilitator. I couldn’t use my design skills in that moment to support the co-design process. However, it could become very easy for the designer to lead or influence the outcomes too much in that role. The value of my being there was only exposed later, when creating the initial script and refined storyboards.

The process of sketching out the image cells for the refined storyboard allowed me to think about what shots I wanted to convey about the experience. During the process of writing the script, I started to build a mental picture of what I thought was important for the viewer to see. I kept the sketches simple and a little ambiguous so the scenes
could be open to interpretation by the co-designers (McCloud, 1993; Gaver, 2003). This was important so the co-designers could still actively contribute to the storyboard. The process of sketching also allowed me to think about the different shots I would need for the video. The ambiguous nature of the storyboard sketches would later also help my technical directors to make suggestions and propose alternative or additional shots needed to convey the story fully during filming.

I met one-on-one with returning stakeholders from the workshops and interviews. I asked each stakeholder to read through the refined storyboard scenario and respond out loud to the story. I wanted to understand if the narrative seemed believable from their perspective. If there was something that didn’t sound right, I adapted the storyboard in that moment. I would then revise the storyboard before meeting with the next stakeholder. Meeting one-on-one allowed me to engage in a more collaborative manner with the stakeholders and use more of my design skills, such as sketching and storyboarding, during the session. Meeting with a cross-section of stakeholders from the initial workshops and interviews also informed the storyboard from the different perspectives of student, instructor, faculty and support staff. Each was able to add more depth or detail to the story.

The storyboard also became a recruiting tool for when I was looking for theatre students to join the project as actors. Unexpectedly, it would also become a successful tool when co-designing the application, one-on-one with stakeholders. It supported the process by placing the application within a context of use that focused the conversation on the higher-level considerations, such as the rules that would govern the application.
and how students using the app would interact, as opposed to what shape or colour the buttons should be.

On the day of filming, the technical directors and actors read through the refined storyboard as a way to put everyone on the same page before filming. For the sake of time and location, I decided not to film the scenes in order. Reading through the storyboard beforehand gave everyone a better sense of where in the narrative we were filming, what had taken place earlier, and what was still to come.

During the filming, there were several unexpected outcomes from a design perspective. Witnessing first-hand the interactions between the actors brought the concept to life and were really exciting to see. Being able to control these actions and re-take shots provided me with unexpected feedback and insight into the proposed user experience design. During filming, I found myself asking questions such as: Is this believable? How would students really react when meeting in-person for the first time when the meet up has been facilitated purely online? Being able to gauge how natural or believable the interaction was allowed me to decide if the application should structure the steps to a “create a group” differently. Having the ability to retake or replay scenes during filming gave me the ability to try out different scenarios of use.

How the actors responded to the “instructor help” request feature of the application also revealed unexpected insight. The actor’s body language and tone really changed when they were asked to pretend to interact with a teaching assistant via video call. The tone became more formal and reminded me of how undergraduate students perceive their relationship with instructors. This was made more believable as the actors were all under 20 years of age.
We had two technical directors (camera operators), three actors, eight extras and myself. We filmed at five locations in less than four hours. It was a lot more tiring than I thought it was going to be. It took quite a lot of organization and planning leading up to the filming day. This certainly wasn’t a quick prototyping technique. However, the final scenario video became an incredibly valuable tool for communicating the proposed user experience concept to freshman science students. Two hundred and one students later completed a survey about the application. Of those 201 students, 92% said that the application could, or definitely would, be a useful tool for freshmen students.

4.3.3: Application Interface Development

The mobile application co-design took place over several months. This time I met one-on-one with the different stakeholders to share with them the storyboard that I had developed to convey the student experience. Then using the storyboard and paper phone templates we worked together to create the interface that would govern the user experience. After each meeting, the interface prototype evolved to incorporate ideas and feedback that heightened that experience. The paper prototype then informed a digital click-through prototype that was incorporated into the scenario video, and was evaluated in a usability study.

The storyboard describing the ‘context of use’ (Goodwin, 2009) became a central tool for co-designing the application interface with the stakeholders. The storyboard helped to shift the focus away from its being an exercise in aesthetics, and towards a discussion and debate on the ‘rules of interaction’ and experience from the perspectives of the students and faculty involved. It also established the scope of the development.
The one-on-one co-design meetings for the application felt very fluid and in all sessions I was able to bounce ideas about with the co-designers and mock up in real-time the interface prototype that became an embodiment of that discussion. That is not to say that the collaborative sessions early in the process were not collaborative or unproductive. However, the role I chose to take on in the moment of the generative sessions has been that of a researcher, not a designer. I did not want to lead or shape the outcomes and wanted the stakeholders to reach those decisions as a collective. However, in the one-on-one development meetings, I took on a more active role that allowed for a sharing of ideas. I originally thought this was due to the number of people involved. On further reflection I realize that my attitude and approach were different for two reasons: we were still generating ideas but with a specific focus and intention, this is an area that I am more familiar with, so I took more of an active role. Second, the brief was co-designed by all the stakeholders I met with so they had more ownership and authority too.

The paper interface prototype is a physical thing. It is an artifact that evolved over time. I was co-creating with stakeholders, mentors and peers on paper what the interface would look like, but this wasn't an exercise in aesthetics. The process of discussion and sketching allowed us to co-design the rules of interaction between the people using the application. The physical interface grounded the conversation, but we didn't talk much about aspects such as what colour the buttons should be, that came later.

The low-fidelity nature of the paper mock-ups enabled the stakeholders (and myself) to challenge and change the interface and therefore the eventual student experience. This process allowed my co-designers and I to make sense of the students’ and faculty’s experiences of deploying such an application. This was far less true once a
digital, click-through prototype was developed. At that point the engagement became more congratulatory, only bringing up minor details related to the workflow. This can be attributed to the stakeholder’s being involved and hashing out the major issues before committing to digital. However, even when stakeholders that were not involved in the paper prototyping phase were asked to provide feedback, the larger challenges or concerns faded away. The fidelity of the interface prototype certainly changed the way the stakeholders engaged with it. “The users need to [be] able to construct relevant appropriations, and spin-off ideas, with the proposed prototype. A prototype in an unfinished form fosters the user engagement allowing the system to adapt to user experience.” (Bellucci, 2015) Providing the co-designers with low-fidelity materials not only invites them more into the design process, but also better engages their creative abilities. “The unfinished quality is appreciated for its ability to engage the creative powers of the beholder’s imagination. Uncertainty and ambiguity can create intriguing feelings, which makes us slow down, think and explore.” (Seok, 2014)

I thought of ‘the prototype’ as a physical thing. A mock-up. Is a sketch a prototype? Carolyn Snyder, author of the book ‘Paper Prototyping’ would suggest that a simple sketch couldn’t be defined as a prototype (Snyder, 2003). The sketch needs to be approached and engaged by the people using it in a certain way. There needs to be an element of make-believe/role play to turn a paper sketch into a prototype. The introduction of the storyboard helped to support the role-play aspect of the engagement with the paper prototypes. For this reason I believe the sketched mock-ups of the interface became prototypes. As the design focus shifts from the immediate touchpoint or
interface and begins to consider the holistic experience, the introduction of methods or tools that support looking beyond the screen become more important.

When thinking about experience, if I sketch out the different cells of a storyboard and play it out with people as we discuss what the experience might be, is that now a prototype of experience? Or do we need to physically act it out? (e.g., through body-storming, improv, enactment) My experience would suggest that it was more than just a sketch; it was a means to communicate something that hasn't happened yet. A future experience or possibility. One that is not focused on the interface but on the actual experience of use. If you remember, “a prototype is a story or a fictional depiction of a product [service, experience, etc.]. The prototype is not the actual thing that we want to build; it is an example, a rough approximation of the thing we hope to one day build.” (Johnson, 2011) The advantage of the paper storyboard is that it is very approachable, portable and low-cost.

The application interface development was the most co-creative of the three deliverables that were iterated on from the first phase of the co-design process. While co-designers throughout the co-design process informed all three ideas, the co-designers most regularly informed the interface design.

4.4: Overall Process Reflection

Every stage of the process wasn’t defined up-front before the engagement began. There was an initial planning phase where goals were defined, but the route taken to reach those goals wasn’t clear in the beginning. “The Design Thinking process is based on the intuitive workflow process of a designer.” (Rhinow, 2013) An element of
improvisation is required to ensure that a co-design project reaches its goals and has actionable outcomes, much like any design process that begins in the fuzzy front-end. The ability to react and push the project towards a successful outcome depends on the experience and expertise of the designer. As a designer I know to trust in the process and when ambiguity can become a resource (Gaver, 2003) to be leveraged to create something unexpected. Not everyone is comfortable with this level of ambiguity, especially those that come from a scientific background. When working in the space between research and design (Sanders, 2015) having a designer onboard that can embrace the ambiguous nature of things is very important. If a designer or researcher does require to improvise during the process it is vitally important, as highlighted by the rough storyboard activity versus the vision maps, that adequate pilot testing be conducted in order to refine and create methods or tools that enable the co-designers to be successful creatives.

The role of the designer in the co-design process as facilitator and interpreter is also an important one, e.g., being able to make connections and visualize possible solutions and concepts so they can be communicated effectively beyond the internal stakeholder group. I witnessed this when I asked the participants to storyboard in detail the proposed student experience. I could picture in my mind the panels of the story taking shape, but the participants really struggled to translate their rich discussion into a visual narrative. However, there are times when playing the role of facilitator can restrict the designer’s being able to leverage their design expertise during larger group sessions where more guidance is needed. The designer should be in the room, however, playing
the role of facilitator may not have been a role best suited in order to take advantage of their ability to give form to ideas.

Throughout the co-design process, as the designer and facilitator I did not want my own interests to influence the outcome. On reflection, perhaps my interest in mobile development did influence the outcome. The fact that 4 out of 7 of the prototype seeds generated were app based might lead me to think that I was placing my own influence on the process and guiding the outcome. However, the faculty and staff were also looking to ways in which the virtual experience could be improved, so it is undoubtedly a combination of mindsets.

Raising the fidelity of the prototypes to be understood and examined by an external audience is certainly a role that the designer is best suited for, if they fully understand the ideas being proposed. Being ‘in the room’ is important for the designer to gain this understanding. Communicating to an external audience is something that Matt Ratto also recognized as a problem with this type of low fidelity making and discussion. “It remained (and remains) quite easy for external viewers to misunderstand either the intention of the exercise or the relevance of its results without extended commentary such as this article.” (Ratto, 2008)

One benefit of working with the same group of stakeholders throughout the co-design process is the co-designers’ levels of engagement. In the beginning of the study, Dr. Andrew Heckler struggled to recruit stakeholders even though there was a large pool of participants to pull from. When I first met with the participants during the interviews some were uncertain about what the purpose was and were reluctant to commit their time. However, once those stakeholders became part of the co-design process it was fascinating
to witness the engagement of some of them increase dramatically. This could be witnessed through the increasing amount of time they were willing to commit to our sessions and also the improved response time to emails. It could also be observed through the stakeholders’ recruiting of other people and resources to the project that weren’t part of the original sessions. Using the Ladder of Citizen Participation (Arnstein, 1969) as a gauge, many stakeholders started out on the level of “Informing” but eventually moved up through the levels to “Partnership” by the end of the process. This is an advantage that has been witnessed in Participatory Action Research (Howard & Somerville, 2014) projects also.

Figure 43: "A Ladder of Citizen Participation" by Sherry Arnstein
Co-designing with a small, carefully selected mixed stakeholder group allows for the designer to build relationships and gain a unique understanding of the given problem. Even though the group might be small, if the group represents the various stakeholder perspectives, their unique perspectives and knowledge on the subject can ensure that the ideas generated will improve the current situation and appeal to a wider audience. The concept generated and developed through the co-design process was validated by a quantitative survey amongst freshman science students that found overwhelming support for the concept.

The process of using a quantitative survey to confirm beliefs and validate concepts generated through a co-design process is a powerful means to support the outcomes. This model of quantitative studies to validate smaller qualitative research and design processes is already a standard activity in practice.
Chapter 5: Conclusion

“Not mega-utopias defined from the top down but seven billion little utopias emerging from the bottom up, facilitated by, not determined by, design.” – Anthony Dunne

5.1: Introduction

As a designer trained with a set of modernist design skills, I wanted to know how much of my training could or should be transferred over to prototyping experience with co-designers to tackle complex problems. I believe that I was successfully able to adapt some of my modernist design skills to the new role, approach and materials, but also learned new skills along the way.

My goal was to add my voice to the discussion surrounding the emerging roles that designers are finding themselves in between research and design. I believe the key findings from my literature review and insights gained from the first-hand experience of prototyping with co-designers have given me that voice.

The following conclusion is divided into five sections that reiterate and answer key research questions, highlight findings from my literature review, introduce new findings from my co-design process and explain how this work can benefit future designers and researchers wanting to support co-design by using prototypes.
5.2: Research Questions

As I describe my findings in this final chapter I will point out when these questions are answered. To reiterate, my original research questions were: How can prototypes be used to generate new ideas and reflect on the proposed experience? What are the roles of the designer (and the co-designers) in the co-design process? How can co-designers be supported to collectively prototype an engaging experience that meets their future needs and goals? How can co-designers remain as active voices as the design process moves into development?

5.3: Key Questions and Findings from Literature

There were several questions that arose from my initial literature review. The following section aims to answer these questions based on my primary research and continued secondary investigation.

The first question that came up during the literature review was, could prototypes be used as a tangible means to act as a focal point or frame a discussion about a future experience or system? This question can be, in part, answered by the second question. Can designers redefine the role of the prototype to communicate matters of concern with an audience that lives beyond the realm of design? Latour and Ehn consider experience to be a matter of concern. The prototyping materials provided to the co-designers during the first two workshops successfully enabled them to frame their discussion and communicate their thoughts on what an ideal experience could be. If we consider experience to be a matter of concern, then prototypes can both frame the discussion and communicate matters of concern. The materials should be abstract in nature to provide
flexibility of interpretation and expression at this stage. Level of fidelity is not as important a consideration when thinking broadly about experience compared with how the prototype will be used in the context of the workshop/session.

The scaffold that supported the co-designer collaboration consisted of designer-made prompts, questions and process. These become more important considerations than materiality for the designer of the session as they dictate the scope and frame the problem space. These considerations greatly influence the context of engagement with the prototyping materials and therefore need to be thoughtfully considered from the perspective of the goals and scope of the activity.

Fidelity, however, became more important to keep the co-designers actively engaged in the process as it moved towards developing the tangible touchpoints of the experience. Low-fidelity prototypes provide a materiality openness that allow for more debate over the higher-level concerns and ideas with co-designers. Lower fidelity prototypes enable co-designers to generate ideas, while higher-fidelity prototypes help them to make suggestions for the refinement of concepts and to communicate about them to external audiences.

The second and third questions that arose from the literature review were; If participants were actively involved in the creation, implementation and reflection process, would that generate experiential understanding and new ideas? And, could engaging stakeholders through prototype iteration and discussion lead to reflection on the impact of what is collectively created? Based on my experience of the co-design process, I believe that the co-designers involved were able to contribute to the design process because the prototypes in the development phase engaged them to consider the
experiential understanding of the proposed outcome. This was witnessed during the paper interface prototyping that combined the refined storyboard with the paper interface prototype to support the co-designers to think about the experience of the end-user, in this case students and faculty using the ‘StudyGroup’ application, and how that experience would take place.

Can front-end prototypes act as catalysts for ideation? The implementation of the sketched prototype seeds confirmed that prototypes can act as catalysts in the ideation process. This also connects to the next question that came out of the literature review; does presenting the user with ideas stifle their ability to ideate or does it support the creative leap? The prototypes seeds were presented carefully as ideas that the stakeholders could use to either incorporate into their ideal experience, or not. Through this balanced presentation, the seeds did not stifle the creative activities of the co-designers, and in fact added another layer of richness to the overall vision.

5.4: New Findings from Research through Co-design

The following concluding remarks from the research through co-design process focus on the main themes of the research questions asked as they relate to prototyping in the front-end and designer/co-designer roles in the process.
Figure 44: Phases of co-design process overlay with the ‘double-diamond’ design process diagram.

A series of connected visuals will be used as a framework to support my conclusions. Figure 42 explains the foundational structure of the visuals. The co-design process, like the design process, has both a generative and evaluative phase. In the generative phase, we are learning and understanding in order to generate ideas that answer the question ‘What could it be?’ in relation to the problem. The transition from the generative to the evaluative phase is referred to as the bridge or gap between the two design phases (Sanders, 2015) Successfully transferring what is discovered in the generative phase to answer the question ‘What is it?’ determines how well the
unmet needs are met. Finally, once the design outcome is communicated to an external audience, we ask ‘What do you think?’ about the outcome. During this co-design process, all of these questions were answered through the use of prototypes.

5.4.1: Prototyping in the Front-end

In the front-end of the co-design process, prototypes can become a medium or metaphor to communicate intangible concepts, such as an experience within a context of use, in physical form. As the process moves from generative to evaluative, the prototyping tools might look the same as those used in traditional design development, but the conversation and engagement from the co-designers is very different as these tools facilitated a deliberation that enabled the co-designers to transfer ideas from the generative phase into the evaluative (see Figure 43). With openness designed into the materials and an equal-partners approach taken by both designer and co-designer, the prototyping tools structured and framed the problem just as the earlier vision mapping materials did.
Figure 45: Prototypes used and their fidelity/role
The prototypes used during the co-design process did not share the same qualities throughout the process. The nature of the prototype depended on when it was introduced to the co-design process. In the very early front-end, prototypes were used to communicate higher-level concerns through representing intangible ideas, such as experience, as physical forms. In this project, the forms created were scale models of physical environments that the stakeholder groups were able to play out an experience within. When asked to communicate experience, both groups of participants focused on the environment in which the experience would take place.

Using physical objects to prototype intangible experience is a powerful means to allow internal stakeholders to debate and negotiate what the ideal state might be. The act of co-production creates a shared mental model that supports communication between co-designers that, in turn, supports collective creativity.

The use of front-end prototypes certainly supported the internal stakeholder discussion. However, due to their abstract nature, these prototypes were unable to communicate their meaning as stand-alone objects to an external audience. Creating narrated summary videos of the events that took place in the workshops and the outcomes was an effective means to open the dialogue to other stakeholders or interested parties as informed participants. The video could also live online so people could access and understand the prototypes across time and place. The narrated video itself can be considered a successful high fidelity prototype that communicates to people beyond the internal stakeholders.

As the process moved from generative to evaluative, there was also a shift in the way that the prototypes were created and presented. Later in the process more
traditional means of prototyping such as storyboarding and paper prototyping were successfully used to keep the co-designers actively involved in the process. The approach and interaction between designer, artifacts and co-designers changed over the process as well. Using low-fidelity storyboards and paper interface prototypes enabled the co-designers to actively contribute to the concept, not just as end-users or testers, but as active collaborators. As the fidelity of the prototypes increased, the co-designers’ ability to provide more telling contributions towards the overriding concept or ‘rules of engagement’ diminished.

5.4.2: Designer and Co-designer Roles in Co-design

In the beginning of the collaboration between the physics education research co-designers and myself, there was a lot of uncertainty. The process started with my interviewing individual participants, but evolved into a group of co-design stakeholders that acted much like a lean startup group. The start-up is a “human institution designed to create a new product or service under extreme uncertainty.” (Ries, 2015) I will use the lean startup formula as a way to make sense of the process that I, as the designer, and the co-designers went through.

Through the process of co-design we learned together and became more certain about the ideal experience, generating lots of ideas in early interviews and workshops that were eventually boiled down to a single, implicit hypothesis. In this project, the hypothesis was that a GPS-enabled study group application would positively support more collaborative learning amongst freshman students. The role of the prototypes at the front-end was to support internal communication and to problem find, as opposed
to problem solve. The collective hypothesis evolved through co-designing the app interface and refined storyboard. These prototypes both contributed to a non-technical ‘minimal viable product’ (MVP) in the form of a live-action scenario video. This video was then presented to 201 freshman students as a way to validate our hypothesis. The video cannot be considered a MVP, as it did not put the device into the hands of the students to use. However, it did validate our learning and convinced us to ‘persevere’. If the concept had received poor feedback we may have opted to ‘pivot’ and go back to the other ideas that were generated in the early phases of ideation through prototyping.

5.4.3: Roles of the Designer

![Figure 46: The roles of the designer throughout the co-design process.](image)

As we went through the co-design process I took on different roles to facilitate and sometimes lead the creative endeavor (see Figure 44). In the beginning I acted as interpreter of the stakeholder needs. I also acted as facilitator, sensemaker and form giver,
but I felt my overriding role was that of a guide.

**Designer as Process Guide**

The designer acts as a process guide throughout the co-design process. A design process guide. An expert that is familiar with the terrain and knows how to reach the eventual destination, even if that is not defined in the beginning. I had to take an improvisational approach while the co-designers and I moved from the fuzzy front-end towards the final outcome deliverables. The ability and expertise of the designer to ‘change things up’ and know when to step in or out of the process is crucial for a successful co-design project to have tangible outcomes and be a true reflection of what the co-designers need to improve their experience. This success is also achieved up front during the planning and designing phase to understand what prompts, questions or materials should be used. This part becomes more challenging for the designer or researcher as the amount of methods and tools continues to increase. The designer becomes the creator of scaffolds and materials that facilitate the co-design process and help to foster relationships between the internal stakeholders. When co-designers are provided with this framework or scaffold of materials and processes, it enables them to apply their knowledge of experience or given field and be creative. Doing this throughout the co-design process, especially when crossing over phases, supports their contribution and active involvement into the development phase.

The co-designer is the expert in their given field or experience. This gives them a unique perspective. If a group of co-designers with different perspectives around the same issue are brought together, their collective learning allows them to become greater
than their individual parts. If the co-designers are carefully selected stakeholders, then a relatively small group of people supported by a designer/guide can build and create outcomes that can be validated by a much larger audience. Facilitating this collaboration and learning process is the responsibility of the designer. Supporting co-designers to actively make and give form to their ideas enables the transfer of knowledge to be successfully represented in the final outcomes, and means the outcomes are a true reflection of their intentions.

**5.4.4: New and Emerging Roles of Designer**

As well as the roles mentioned above, unexpected roles of ‘seed planter’ and ‘fidelity-raiser’ were identified through my primary research as important roles that designers should be aware of when going through the co-design process. The way in which designers can make sense through sketching also became apparent.

**Designer as Provocateur (Seed Planter)**

When presented in a ‘take it or leave it’ manner, prototype seeds can frame problems and give co-designers the means to challenge or accept new, potentially disruptive, ideas while building a shared vision of a future experience together. These seeds enable the designer to frame and position the discussion by providing offerings that can be incorporated into an ideal vision, as opposed to a blank canvas. The ability of the designer to communicate these ideas in a balanced manner determines how influential the seeds are. If taken a step further, seeds can become prototypes. However, seeds in physical form place a greater focus on the idea and can consume the stakeholder
discussion (McKenzie, 2015). This can be advantageous when wanting to direct the co-designer’s focus, but can also lead to the designer’s controlling the outcomes. Well-positioned seeds strike the right balance and can be incorporated into a framework or scaffold to enable co-designers to be creative, without directing the outcomes.

**Designer as Liaison (Fidelity Raiser)**

The designer contributes in, perhaps, the most obvious way by being able to take the low-fidelity, rough prototypes created by the co-designers and produce higher fidelity prototypes that can effectively communicate the idea or concept proposed to the world beyond the immediate stakeholders. This becomes hugely important when attempting to validate a concept or bring other people in the process. To fully realize the higher fidelity prototype it is imperative that the designer be involved in the process from the beginning, instead of being handed-off with outcomes of the early phases of the process. This enables the group and the ideas to cross the bridge between the research phase and design phase successfully, as opposed to ideas being lost or ‘falling in the gap’.

**Designer as Sense-maker (Sketching to Understand)**

Finally, although this is an already emerging role, I naturally used sketching as a way to make sense of the envisioned experience. When presented with a lot information, designers have the ability to iteratively sketch in order to understand and make sense of how information and ideas can connect in complex situations. Through this process of iteration, the sketch can then convey these connected ideas to an external audience in order to simply and effectively communicate systems in a more engaging way.
5.4.5: Involvement of Co-designer

As mentioned in the background study, co-designers are experts in their given field or experience. They can enter the process at a certain level of participation, but can soon become active collaborators, validators and even champions and partners if the process engages them appropriately over an extended period of time. Figure 45 shows the participation of the co-designers as they went through the co-design process. Inviting them into the process from the beginning created engaged co-designers. Once co-designers have been engaged in early ideation and take ownership of the ideas generated, they become partners in the process. Not all the stakeholders continued into the evaluation phase, but those that contributed as we crossed the bridge into the evaluative phase became more than just informants or participants, even inviting other stakeholders into the process to drive development (represented by the dashed lines connecting participants).
5.5: Contribution to Design

To summarize the points made in the previous sections of this conclusion my contribution to design is as follows:

Introducing designer-made ideas into the front-end of the generative design process (prototype seeds), informed by stakeholder interviews, can push co-designers to consider otherwise unimagined alternatives and provoke innovative application of emerging technology.

Figure 47: Co-designer involvement over the course of the project.
Repositioning prototypes as matters of concern (vision mapping) in the front-end of the generative phase can give abstract notions such as a new experience or service physical form. This type of prototyping helps co-designers to create a shared mental model (in physical form). This enables the discussion to be more aligned and helps set an agreed upon direction for the future.

Iterating across the bridge from generative to evaluative with co-designers can successfully transform ideas into concepts that become a true reflection of the generative phase and address unmet needs. In the future, more focus on this area between the phases and how co-designers and ideas are transitioned from one to another will be important.

During the co-design process I tried out new and established roles that a designer might take on during co-design. The overriding role of ‘design process guide’ became an important new role that I took on to ensure the co-design project would be successful while still being led by the needs of the co-designers, not my own self-interest. This role requires a higher level of expertise than other roles mentioned, as it requires a holistic view of the design process and self-awareness.

A major advantage of the designer being part of the co-design process is the added ability to communicate to an external audience the ideas and discoveries that happen during the generative phase by raising the fidelity of the ideas that were received first-hand by the designer being in the room during the generative phase with co-designers.

The method of paper prototyping with co-designers, in combination with the refined storyboards developed from initial co-designer rough storyboards, is a new and promising application of already established prototyping tools to help bridge the generative and evaluative phases of the co-design process to keep co-designers actively involved.
From a learning sciences perspective, the success of having student perspectives represented in the creation of an ideal learning experience became very valuable during the process. I believe their representation was critical to the eventual positive support from a larger student population. As more educational tools become available, it is incredibly important that the students those tools are meant to benefit from are involved in the design process.

5.6: Future Work

There are several promising areas of continued exploration that could branch off from the findings and areas that were considered beyond the scope of this study. The following lists future work divided by the generative phase and the bridge between generative and evaluative phases.

**Generative Phase**

Prototype seeds were informed by early stakeholder interviews. Further exploration into the role of prototype seeds to push co-designers to imagine radical, more speculative futures during generative design sessions is needed to understand their true impact. Understanding the impact that on-paper versus physical mock-ups of the same idea has on the outcome of generative sessions with stakeholders will also need further exploration.

Concepts co-created in generative sessions could be quickly prototyped to a high fidelity and placed in real world scenarios that allow the co-designers to experience in-situ use, first-hand. These could potentially help span the bridge between generative and evaluative phases.
During the vision mapping workshops, students and faculty created separate visions of an ideal learning experience. When they came together in the final workshop to share their visions, we simply discussed where there was overlap. Getting the mixed stakeholders to co-create a shared vision with the same materials might have generated new ideas and a more complete shared mental model.

The vision maps became stages that the co-designers used to describe their ideal experience from a high level. Embracing this and getting the co-designers to act out first-person scenarios using the vision maps from different stakeholder perspectives could produce more complete scenarios that could be later storyboarded.

I used sketching as a means to understand and convey the journey map that was created that captured the overall ideal experience. Exploring how designerly skills such as iterative sketching are being applied to ever more complex concerns and challenges, as a means not only to communicate but to also make sense of problems requires further investigation.

Finally, the choices that I made throughout the process on which methods to support the co-design practice and what direction to move in could be the subject of a future study. This could examine the reasoning behind how methods are selected add insight to the internal process that a designer or researcher goes through when creating new methods, process or methodology.

The Bridge/gap

The space between the generative and evaluative phases of the process, where ideas and understanding are transformed into concepts became important in order for the ideas
generated to be successfully realized. Exploring methods and tools that engage co-designers in this space between the open generative front-end, and the closed evaluative end would be a valuable area to focus on.

I created a live-action scenario video after several storyboard iterations with my co-designers. I was surprised by how bringing the concept to life with actors and props really helped me to understand the proposed experience. Involving the co-designers as directors and actors in the scenario film creation could lead to a greater understanding and act as a discussion point that could further transfer the ideas and knowledge from the generative phase, into the evaluative one.

5.7: Final Thoughts

When I began this thesis my research motivation was to understand how my modernist design training could be applied to tackling complex problems that require the involvement of various stakeholders; often with a focus on systems or experience, as opposed to products or stand-alone artifacts.

Through this process of learning by doing, of research through co-design, I have expanded by definition of what a prototype is and learned new way to communicate ideas and concepts. I have a greater sense of how I can contribute to complex problems by adopting co-design as a mindset and approach in order to bring together people and actively understand and co-create to improve the current state. This has been an incredibly rewarding experience for me and I intend to take the processes, methods, tools and mindset that are a product of my thesis work and apply them in practice and have an impact in the space between research and design.


   Bloomington, IN: Indiana University Press.


   http://www.academia.edu/6258209/Prototypes_for_Innovation_Facing_the_Complexity_of_Prototyping


Appendix A: Initial Interview Questions

1. So, just some quick questions to start us off, what is your name and position within physics education at OSU?
2. How are you connected to the Physics Education Research and Introductory Physics?
3. What drew you to study Physics?
4. What are the main reasons for students taking the Introductory Physics course?
5. Can you describe for me your experience of Introductory Physics?
7. You are probably familiar with the essential skills for Introductory Physics, can you explain the purpose of the online platform?
8. What do you think the successful elements of the current online experience are? What are the drawbacks or downsides?
9. Here is a deck of cards with inspirational content on each. What I would like you to do is look through this deck and pick out four cards that represent something you would like to see happen in the future regarding introductory physics, and two cards that you don’t want to see happen in the future. You will have about 5 minutes to look through them, feel free to ask me any questions or think-out-loud while you are working.
10. How could a new virtual learning experience for Introductory Physics help create a better learning experience for students and faculty? What principles should it have? What should be the goals or objectives of such an experience?

11. Finally, do you think a new virtual learning experience for Introductory Physics could nurture a sense of community, identity or belonging? If so, how?

12. Do you have any questions for me before we end this interview?
Appendix B: Initial Interview Image Card Deck and Results
Image Deck Cards 1-15

Image Deck Cards 16-30
Image Deck Cards 31-45

Image Deck Cards 46-60
Image Deck Cards 61-68

Card Sort Results: Positive Future
Card Sort Results: Negative Future
Appendix C: Current Experience Collage Materials and Outcomes
Collage material set of assorted paper shapes

Word stickers included in collage materials set
Systems Manager Staff participant outcome: “The Physics Education Research department does a lot of great educational related studies on how to improve learning. However, we aren’t very good at applying it to our own courses. It often goes out and is used elsewhere. We need to be doing a better job.”
Course Materials Creator faculty participant outcome: “The connections between the three modes of learning; lecture, lab and recitation only exist in the course creator’s mind. The students aren’t aware, and we aren’t doing enough to make it easier for them to see the connections.”
Graduate Instructor participant outcome: “These are my students. I am stand at the front of the class. One student really gets what I am explaining, most try not to stand out too much and the ones that really don’t know what I am talking about fall back on their phones for answers.”
Adjunct Faculty participant outcome: “Students are often distracted by earning money, working out, playing on their phones or at worst don’t show up to class. The faculty member is loved because he makes Physics fun by incorporating cat videos.”
Tenured Faculty participant outcome: “The student (in the center) has so many things going on in their lives that it is so hard to get them to sit down and focus. We make it worse by cramming a load of information in each class with unrealistic expectations on how much they will take in.”
Freshman Student participant 1 outcome: “Everything in the top left are the things I have to do. The top right is my family and my home that I miss. I guess I am still adjusting to being independent. The lower half of the page is what I want to be doing most of the time and the things I love. It is a struggle to balance the lower and upper halves.”
Freshman Student participant 2 outcome: “This is the process of going to school. There are lots of resource and tools to choose from. I go through a process of asking questions and findings answers. This usually leads to more questions and answers. This becomes a cycle until one day I will graduate with no money!”
Appendix D: Prototype Seeds

Idea #1: Pop-up Group Study App
An augmented mobile application that allows students to announce where and when they decide to group studying by pinging their GPS location and notifying other students on the program.

Idea #2: Live Stream Prob Solving
Short tutorial videos live streamed that show how to solve the problems that are presented while explaining the concepts. These can be broadcast by instructors, graduate teachers or students, then rated.

Prototype Seeds 1 and 2
Idea #3: Structured Study Group

This mobile application allows instructors to assign groups and specific problems and acts as a platform for the group to chat online, and arrange to meet offline for studio-based styled learning.

Idea #4: Instant Bulletin Board

An instant messenger board that enables students, grads and faculty to create public or private discussion groups, share resources and post interesting or related content.

Prototype Seeds 3 and 4
Idea #5: Gamification of Essential
Introducing a networked game (multiplayer) aspect to the current essential skills that could set challenges, unlock rewards and incorporate collaborative or competitive elements to the current experience.

#5

Idea #6: Interactive Essential Skills
An interactive installation that allows the students to complete the essential skills requirement using a mixture of physical objects and multitouch or motion tracking screen interactions. This could be set up in the studio-styled learning spaces.

#6

Prototype Seeds 5 and 6
Idea #7: Virtual Office Hour

This video feed would allow students who live off-campus to ‘drop-in’ on the office hours, either through live stream cam or VR.

Prototype Seed 7
Appendix E: Vision Map Materials

Material set for Vision Map activity
Canvas and additional materials for Vision Map activity

Workshop 1: Faculty and Staff Vision Map, annotated outcome
Workshop 2: Student Vision Map, annotated outcome
Appendix F: Rough Storyboard Materials and Outcomes

Rough Storyboard prototype materials
Rough Storyboard canvas
Group 1 Rough Storyboard outcome: “GPS-enabled study group app”
Group 2 Rough Storyboard outcome: “Structured, in-class study app”
**Appendix G: Refined Storyboard Prototype**

<table>
<thead>
<tr>
<th>Location: Dorm</th>
<th>Number: 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: Its Sunday night, Jamie is in her dorm room on campus working on her vectors assignment for Intro Physics that is due Monday morning. She is struggling to understand the concept and can't solve the equation. Its the beginning of the semester and she doesn't know many people in her class. She is tempted to look on yahoo answers but decides to send an email to her teaching assistant, however, it's after 6pm so she isn't convinced the TA will respond in time.</td>
<td></td>
</tr>
<tr>
<td>Duration:</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location: Dorm</th>
<th>Number: 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description: She is tempted to look on yahoo answers but decides to send an email to her teaching assistant, however, it's after 6pm so she isn't convinced the TA will respond in time.</td>
<td></td>
</tr>
<tr>
<td>Duration:</td>
<td></td>
</tr>
</tbody>
</table>
Greg is in the library trying to solve the same vector assignment. He sort of knows a few of the other people in his class but not well enough to reach out to anyone. He hasn't been going to meet with his TA so doesn't think to email her.

(Unexpected) Jamie uses the Group Study App to search for other classmates nearby that are active. The app displays a map, and using GPS, shows Jamie the location of classmates that are also online. She selects a classmate in the nearby library (Greg) and opens a chat option.

Jamie: "Hey, are you working on the vector problems for tomorrow?"
Greg: "Yeah I was, couldn't get questions 5, 6 OR 7 :(")
Jamie: "Me too. I sent my TA a message. Want to meet? I can come to the library."
Greg: "Yeah sure! I will be here."

Jamie selects the "Join" option that is part of the chat function,
Location: 18th Ave. Research Commons
Description:
Greg accepts the request.

Location: Dorm
Description:
Jamie packs up her stuff and heads out to the library.

Location: Campus
Description:
While she is walking she checks Greg's profile to find out what he looks like.

Refined Storyboard page 4 of 9

Refined Storyboard page 5 of 9
Location: 18th Ave. Research Commons
Number: 11
Description: She arrives at the library and finds Greg.

Duration:

Location: 18th Ave. Research Commons
Number: 12
Description: They chat briefly then open up their laptops.

Duration:

Refined Storyboard page 6 of 9

Location: RPAC
Number: 13
Description: Mackenzie is just leaving the RPAC. She wants to finish her vectors assignment and checks the Group Study App. She finds a group of two that are working in the library. She selects the join option and heads in that direction.

Duration:

Location: 18th Ave. Research Commons
Number: 14
Description: Mackenzie arrives at the library and the three of them work together on the problem.

Duration:

Refined Storyboard page 7 of 9
After a while, it is obvious that they can't solve question 7. At that point, they send out a "Help Request" to any active TAs or Faculty online.

Nathan is one of the TAs connected to the Intro Physics course. He is working at home and gets a notification about the request. He opens up his laptop and connects to the group. He has the choice of a video call or messenger option. He chooses the video call and waits for the group to answer.

The group are successful in completing their assignment.
Appendix H: Paper Interface prototype

Paper prototype app interface version six (part 1)

Paper prototype app interface version six (part 2)
Paper prototype app interface version six (part 3)

Paper prototype laptop interface version six (part 1)
Paper prototype laptop interface version six (part 2)
Appendix I: Digital Interface prototype

Home screen (left) and Subject screen options (right)
GPS permission (left) and Map view of active study groups (right)

Study group profile (left) and study group message feature plus join request (right)
Join group confirmation prompt (left) Request accepted notification (right)

Directions to study group location (left) Multi-person study group profile (right)
Request virtual support options (left) notification of help requested (right)

Closed group state change (left) other group profile options (right)
Group filter options (left) study group choices after filter (right)

Map view of study groups open (left) list view of same options (right)
Settings and edit profile options
Appendix J: Executive Summary of Survey Results

Executive Summary: Intro Physics/Chemistry Student Survey Results
05/10/2016

The following is an executive summary of a survey that was designed to understand current student learning habits and gauge their response to an application concept developed as part of a co-design project between the Physics Education Research and Design Departments at The Ohio State University.

Dr. Andrew Heckler and Dr. Matt Stoltzfus sent the survey to their Intro Physics and Chemistry students, respectively, at The Ohio State University. Mostly first year students take the classes. Results from the survey include responses collected between the 10th and 17th of April 2016 using Google Forms as the platform.

201 students participated in the survey. 80% of those students were Chemistry students. 67% of students that took the survey were female. 85% live in a dorm on campus. A range of GPA scores were represented. No question was mandatory.

Current Study Habits Summary:

The first part of the survey focused on the current study habits. The following are the results and observations based on the data collected.

1. Where do you typically study (homework, test prep, etc.) for this course outside of class? Check all that apply.

Overall, this confirmed the assumption that freshman students mostly study in their dorm room or in the library. Students were also asked why they chose to study there. The most common reasons were: convenient location, quiet place with no distractions. A comfortable environment
became a common factor across many of the responses. Many students spoke of using the residence hall group study spaces as they could work together and get help from other people.

2. When do you typically study outside of class?

Students could select multiple answers for this question. Students typically study throughout the day, with few studying in the morning and most studying in the evenings. Students study evenly across the weekdays and weekend.

3. How much time do you spend doing homework, test prep, etc. outside of class in a typical week?

77% of students claimed to spend 3+ hours studying during a typical week.
4. Who do you typically study with?

The majority of students study alone with only 27.5% working with either friends or classmates. The students who did study with someone commonly said they met their study partner(s) through their dorm (same floor or roommate), class/ lab or extracurricular groups.

5. Which of these help you the most when studying outside of class?

Students were able to pick up to three resources. Online videos, textbook, other students and Yahoo Answers polled the highest. Online videos were preferred by students because they could watch them repeatedly to understand; many students also self-identified as visual learners. Textbooks were preferred mainly because that was ‘how the course is taught’ and a source of reliable information. Even though 70% of student said they studied alone, they viewed their peers as resources that could help them to talk through or explain problems. Yahoo Answers was preferred for many reasons, with the overriding theme being it was the quickest way to get the right answer.
6. What do you think are the best study habits to be successful in this course?

This question was the most open-ended. The overriding themes for students to be successful were managing their time effectively, practicing problems everyday and not cramming, staying ahead of the materials and not falling behind.

7. Do you feel connected to the students and instructors in the course? How?

184 students answered this question. 56% said they felt connected, 19% said somewhat, while 25% said no. Of the students that did feel connected, the common reasons that came up were Learning Catalytics, Perusall, and the Instructor (Dr. Fus was mentioned a lot). Students indicated that groups can form based on abilities; segregating the good and poor students.

Study Support Summary:

Students had to respond to the following statements using the Likert scale. Overall, Students responded the most positively to being able to work with other students when studying for a test or quiz. Students also responded very positively to being able to schedule times to meet with the instructor, instead of having to attend office hours. Student responded positively to communicating electronically with instructors, but would prefer to schedule and meet with them in person. The response was also positive to being able to meet up with fellow classmates. The ability to communicate electronically with fellow students generated the most neutral response.

1. I would work with the instructor or TA more if it were easier to set up an in-person meeting time when I am available.

Students responded very positively to being able to schedule times to meet with the instructor, instead of having to attend office hours.
2. I would work with the instructor or TA more if it were easier to communicate electronically.

Student responded positively to communicating electronically with instructors, but would prefer to schedule and meet with them in person.

3. I would study with my classmates more if it were easier to set up an in-person meet up time and place when I am available.

Students were asked if easier meet up with students would facilitate more peer-to-peer learning. The response was positive to being able to meet up with fellow classmates.

4. I would study with my classmates more if it were easier to communicate electronically.

The ability to communicate electronically with fellow students generated the most neutral response from the students.
5. I like the idea of working with classmates on homework.

Students responded very positively to the idea of being able to work with fellow classmates on homework.

6. I like the idea of working with classmates to study for a test/quiz.

Students responded the most positively to being able to work with other students when studying for a test or quiz.

StudyGroup Application Results:

1. Do you think an application like this would be useful for freshman students?
Students responded very positively to the application concept with 92% of respondents saying yes or maybe when asked if it would be useful.

2. Would you use this application if it were available through Carmen?

Interestingly, the number of positive responses dropped when the application was situated as part of Carmen (OSU learning system).
Individual Responses:

Overall, the application was received positively. Students liked the idea of being able to meet with other students to work through problems and get support from their instructor.

“I think it’s difficult for some freshmen to find people to study with on campus, but an app like this would motivate them to form their own study groups. Since it seems very similar to a lot of social media apps, I think a lot of students would utilize it. If it was available to me, I would use it to find study partners.”

“Because often times I will be studying and get discouraged by problems i can't figure out. This could make life easier and even keep you from feeling overwhelmed.”

“It’s frustrating not knowing anyone in class, especially as a freshman, to ask for help on the questions. This is especially true when it’s late and not possible to meet with a TA or instructor; this app seems like a really quick and easy way of getting help on homework questions.”

“I like the idea of being able to find someone nearby you who is struggling on the same thing and being able to work together. Also, I like the feature that allows you to request instructor assistance.”

“Because I often have questions but I don’t know if people are around to help. Also I have had questions when I’m studying in a group, so when none of us know the answer it would be convenient to use video chat with someone who is not around us.”

However, common reasons why someone would not use the application included:

- Feeling uncomfortable to meet up with ‘strangers’
- Simply preferring to work alone
- Uncertain that everyone would use the app for the right/same reasons

Conclusions

Overall, the survey proved to be a useful exercise to understand current student learning habits and gauge if the proposed application would be successful. Some key/unexpected findings included:

- Students would be more likely to use the application if it were centered around quiz or test prep.
- Students would prefer to meet face-to-face with instructors and peers
- When meeting with instructors, being able to schedule a time that suits the student would increase the likelihood of seeking help.
- Online, mobile-based learning tools such as Learning Catalytics had a positive impact on students feeling a sense of community.
- Even though 70% of students said they studied alone, they viewed their peers as the third most useful learning resource.
- Online videos proved to be hugely important for freshman students outside of class.

In terms of the StudyGroup application concept, the students responded positively to the
concept and in-app features. Concerns over security would have to be addressed, emphasis on the students using the application being part of a closed group would help. A feature to report students who misuse the app or a ‘one-strike-you’re-out’ policy could curb misuse. The application would be most helpful in the first freshman semester, especially during quiz and test times. Gaining quick access to instructors was well received. However, based on the study support statement responses, being able to simply schedule a face-to-face meeting with an instructor during a time that would suit the student might be more suitable and attainable. Based on the results of the survey, the concept should be developed further, factoring in the aforementioned considerations.