Master Class Proposal: Making Prototyping Decisions

Engaging students in considering decisions when developing prototypes for their designs

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ABSTRACT

Prototypes are a well-established technique to develop a design concept and evaluate its usability, utility, and functionality, and are commonly taught in HCI courses. In this Master Class, we will cover two dimensions along which it is useful to make informed decisions for creating prototypes: (1) *Filtering decisions* relate to *what* elements of the design are included in the prototype. (2) *Implementation decisions* relate to *how* to create the prototype. Incorporating this topic into HCI coursework helps educators guide students toward becoming more intentional about their prototypes, instead of simply following class instructions or opting for the most common type of prototype. In the Master Class, the topic will be presented, course materials will be provided and discussed, and participants will engage in a hands-on activity to practice the concept and will engage in a discussion about how to apply the topic in their specific teaching circumstances.

CCS CONCEPTS

• **Human-centered computing** → HCI theory, concepts and models; • **Social and professional topics** → Computing education programs.

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1 BACKGROUND: PROTOTYPING IN AN HCI CLASS

A prototype is "a draft version of a product that allows you to explore your ideas and show the intention behind a feature or the overall design concept to users before investing time and money into development." 7. In both HCI research and its parallel UX practice, prototyping is a well-established technique to develop a design concept and evaluate its usability, utility, and functionality, with the intention of improving the design. Prototypes are taught in HCI classes, and they take up chapters or full sections in HCI textbooks (e.g., 1, 4). At Cornell, in the most recent offering of the introductory HCI class in Fall 2022, I asked students in an incoming survey "What are your goals for this class?"; 10 students said "to learn Figma" (a popular prototyping software). We also offer two additional classes dedicated mostly to prototyping, one on web/app prototyping and the other on rapid physical prototyping. Given that prototyping an important topic is HCI education, it merits attention toward how it is being taught. In this Master Class, I propose an approach to teach this topic by paying attention to the decisions one has to make when creating prototypes.

1.1 Prototyping Decisions

Two dimensions are commonly used to distinguish between different kinds of prototypes: fidelity and medium. Fidelity is a continues dimension that relates to the level of similarity between a prototype and the final product 8; the higher the fidelity, the closer the prototype is to the final product in appearance and interaction. Medium is a categorial dimension that refers to the material or form used to create the prototype, typically paper or software 5, 8. Research has shown that both low- and high-fidelity prototypes, made with either paper or software as a medium, are useful for discovering usability problems 5. Especially low-fidelity paper prototypes are easier to create for designers, and less intimidating and easier to critique for users 6.

While these two common dimensions are useful for deciding *how* to create a prototype, there are additional aspects in the construction of a prototype that relate to decisions about *what* to include in the prototype. In their 2008 ToCHI paper, "The Anatomy of Prototypes" 2, Lim, Stolterman & Tenenberg propose a framework for prototype conceptualization using two dimensions, (1) Filtering and (2) Manifestation, where, in each of these dimensions, the designer makes decisions when engaged in a prototyping activity.

The framework is based on the idea that a prototype is an *incomplete representation* of the final product. The *filtering* dimension is based on the *incompleteness* of a product, in the sense that the designer doesn't represent the entire product in the prototype, but needs to choose (i.e., filter) *what* elements of the design to include in the design and which elements to leave out. The *manifestation* dimension is based on the idea that a prototype is a *representation* of the product and is not the product itself. As such, the designer needs to decide *how* to construct this representation. To increase student comprehension, I use the term *implementation* instead of the original term *manifestation* used by Lim et al. Figure 1 shows how the characteristics of a prototype being an incomplete representation map to the filtering and implementation decisions.

1.1.1 Filtering decisions. *Filtering decisions* means deciding for various elements of the design whether they are to be included in the prototype or not. The following kinds of elements are useful to consider when making filtering decisions.

Appearance relates to the visual properties of the design, including colors, textures, sizes, fonts, shapes, and the proportional

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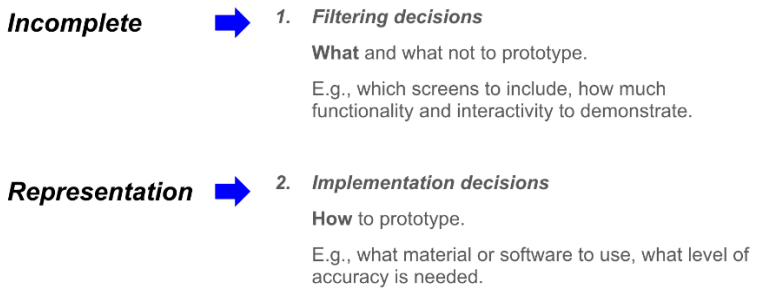


Figure 1: Mapping of the prototype characteristics to the decisions that are made when creating it.

relationships among these elements. For example, a designer needs to decide whether to filter in colors, using the color palette that will be applied in the final design, or to filter this visual aspect out and use black & white. For physical designs, this may also include tactile properties, e.g., physical texture and vibration. For designs that include audio elements, this also refers to the audio properties such as volume and pitch.

Content relates to what data and information are included in the prototype, whether real content, made up (though realistic) content, or absent. For example, content is filtered out when using text placeholders such as "Lorem Ipsum" or horizontal scribbles, and when empty rectangles are used as placeholders for images. Using stock photos to represent imagery is a midway between filtering out visual imagery completely and filtering in real content.

Functionality relates to the functions and features that are represented in the prototype or that are left out. For example, students often include account creation, logging in, and onboarding functionalities when designing mobile apps and websites, and as such, they are filtering in this functionality. Carolyn Snyder uses the terms *breadth* and *depth* to identify the degree to which the prototype shows the variety of features available in the prototype (breadth) and the detail of the implementation of each feature that is applied in the prototype (depth) 6. Prototypes that focus on breadth of functionality are considered *horizontal*, those that focus on depth are considered *vertical*, and those that mix both breadth for some functions and depth for other functions are considered *T-shaped* 3.

Interactivity relates to the ways in which people interact with various elements of the prototype. Filtering in interactivity means that the prototype dynamically responds to user's actions on various elements in the design (buttons, input boxes, links, etc.) by changing screens, visualizations and information provided to the user. For example, a text box that allows the user to enter free text with a keyboard filters in this interactivity compared to a pre-filled text box that filters out the text box interaction.

Guiding principle: how does a designer decide which elements to filter in or out of the prototype? Filtering decisions should be based on where the designer wants to *direct the audience's attention*, given the goal of the prototype (e.g., pitch an early design concept, demonstrate a user flow, run a usability test, etc.). What is filtered in will typically receive the audience's attention, whereas what is filtered out will remain outside of their attention. For example, when designing a prototype to be used for usability testing, filtering out the color palette and keeping it in black & white, allows users to focus on the interaction flow and ignore the color choices. Otherwise, users will likely provide feedback about the specific the color choices, even if those are only used as placeholders and the final color palette hasn't been decided upon. Typically, early prototypes filter out most elements, and as the design iteratively develops more elements are filtered in.

1.1.2 Implementation decisions. *Implementation decisions* means deciding how to construct the prototype that represents the design. The following aspects are useful for considering implementation decisions.

Material relates to the medium used to create the prototype. These could be physical materials such as paper, wood, or plastic and the tools for manipulating physical matters such as scissors, markers, and glue, they can be software prototyping tools, with recent popular choices being Adobe XD, Figma, and Balsamiq. For physical prototypes, materials could include fabrication tools such as 3D printers, laser cutters, and Arduino circuit boards.

Resolution relates to the level of details, sophistication, and accuracy of the prototype. Low resolution prototypes are more rough, coarse, or simplified, whereas high resolution prototypes include more details, with accurate representations that are closer to the final product on the filtering dimension variables of appearance, content, functionality, and interactivity. The resolution can also be hybrid, with some parts at a low resolution and others at a high resolution.

Because students are sometimes familiar with the term *fidelity* to relate to the implementation of a prototype, it is useful to consider it as a combination of both material and resolution. In other words, if the materials used to create the prototype are closer to the materials used to create the actual product, and the resolution is high in that it more accurately represents the final product, then the prototype is high fidelity. On the other hand, if the materials are farther from those used for the final product and the resolution is low, the prototype is low fidelity. For example, for a web app, an HTML front-end only prototype that uses a CSS template for defining the visual style, is considered a high-fidelity prototype. For the same product, a rough hand-sketched paper prototype is considered low fidelity.

Guiding principle: how does a designer decide which materials to use and how much resolution is needed for a prototype? According to Lim et al. 2, implementation decisions should be based on the economic principle of prototyping: the best prototype is one that uses the *simplest and most efficient* implementation. The idea of prototyping is to develop the design in order to test and evaluate what is working and what isn't in order to improve the design. Therefore, spending more time, effort, or money than needed is a waste of resources, especially if the design is likely to change.

1.2 Relevance to the EduCHI Community

Being familiar with and practicing the topic of making prototyping decisions helps students achieve the following learning objectives: (1) articulate prototyping dimensions and (2) make informed decisions about how to create prototypes and what to include in them. For educators, adopting, adapting and incorporating this topic into their own HCI and related courses, helps to guide students toward becoming more intentional about their prototypes, instead of simply following class instructions, or, later as practitioners, opting for the most common type of prototype. Accordingly, the learning objectives for the Master Class are:

- Articulate the types of prototyping decisions and recognize their importance for student learning.
- Apply the topic of prototyping decisions in an educator's specific class and modify existing teaching materials for one's lecture, exercise, homework, and course project.

2 ORGANIZER

Gilly Leshed is a Senior Lecturer in the Department of Information Science at Cornell University. She has been teaching at Cornell since 2010, including teaching a large introductory Human-Computer Interaction Design class (200 students) since 2015. *Making prototyping decisions* is one topic in her class that she has developed over the years and adapted over time to fit students' needs.

3 PROPOSED FORMAT & STRUCTURE

3.1 Introduction (15 minutes)

I will begin the Master Class with an introduction to the topic and its rationale (based on Section 1.1), and the student learning objectives. I will provide the audience with a tool handout (Appendix A.1) and then run a poll, similar to the one I apply in class, in which various snapshots of prototypes are presented and the audience is asked whether elements are filtered in or out, followed by an explanation of the correct answers (Appendix A.2). I will also point out the differences between design decisions and prototyping decisions. To make informed decisions about both the design and the prototype, it is useful for students to understand the difference between these two types of decisions. *Design decisions* are made about the design of the product, and are based on the user's needs and goals, usability principles, aesthetic choices, and more. Design decisions are independent of how the design is prototyped. *Prototyping decisions*, on the other hand, are decisions about what design elements to include in the prototype and how to construct it. Prototyping decisions are based on the goal of the prototype and what it is used for in the design process.

3.2 Hands-on Activity (25 minutes)

I will then simulate an in-class activity with the Master Class participants. In class, students are each given a tub of Play-Doh (a modeling compound) and work in groups of 2-3 to design and prototype together a shoe. They are instructed that they can make any shoe they like; in the past, students have designed sandals, sneakers, high-heel shoes, boots, and more. Figure 2 shows a few of the photos of the shoes that students designed and prototyped in the most recent offering of the class, in Fall 2022. In addition to designing and prototyping a shoe, students are also given a worksheet, which they fill out with their design decisions and prototyping decisions (Appendix A.3).

Given that the master class will be run virtually, participants will be requested to prepare ahead of time any of the following craft supplies: Play-Doh (or another modeling compound), aluminum foil, cardboard (e.g., a cereal box) + scissors + markers + glue/tape, etc. They will be working in breakout rooms to discuss the kind of shoe they are designing, and each participant will individually create their own prototype. They will fill out the worksheet digitally, in an online survey tool.

While participants are working on the activity, I will "walk around" the breakout rooms to answer questions and engage participants in a conversation about pointing out the differences between their design decisions and prototyping decisions, and articulate and justify the filtering and implementation decisions they are making.

Parts 3.1 and 3.2 are designed to achieve the first learning objective of the Master Class, to *articulate the types of prototyping decisions and recognize their importance for student learning.*

3.3 Presentation of Teaching Materials (5-10 minutes)

After going through the main activity, I will present additional ways in which the concept of prototyping decisions can be incorporated into the course materials of an HCI class, to help students further engage and practice the topic. First, when students learn about and practice creating prototypes with paper and software, we come back to the prototyping decisions they are making, for example, by considering how the interactivity is different between paper and software, and the different levels of resolution between the two types of material. When creating paper prototypes, we encourage them to filter out most appearance elements and focus on filtering in functionality and interaction flow. When creating software prototypes, we encourage them to filter in more appearance and content elements, and to add resolution compared to the paper prototype.

Second, for their course project, students are also asked to describe, discuss, and justify prototyping decisions they make when creating prototypes for their project designs, and to distinguish their prototyping decisions from their design decisions. Students are evaluated on their ability to make this distinction, to articulate their prototyping decisions using the correct terminology, and to justify using convincing arguments. This evaluation is meant to assess whether students achieved the learning objective, to *articulate prototyping dimensions and make informed decisions about how to create prototypes and what to include in them.*

Figure 2: Photos of shoes that students designed and prototyped in Fall 2022.

3.4 Final Discussion (10-15 minutes)

Finally, we will hold a discussion in which participants will present their unique teaching situations, and together brainstorm ways in which they could adapt the topic and the teaching materials for their own circumstances.

Parts 3.3 and 3.4 are designed to achieve the second learning objective of the Master Class, to apply the topic of prototyping decisions in an educator's specific class and modify existing teaching materials for one's lecture, exercise, homework, and course project.

4 RECOMMENDED READING

Recommended reading prior to the Master Class:

Youn-Kyung Lim, Erik Stolterman, and Josh Tenenberg. 2008. The anatomy of prototypes: Prototypes as filters, prototypes as manifestations of design ideas. *ACM Trans. Comput.-Hum. Interact.* 15, 2, Article 7 (July 2008), 27 pages. https://doi.org/10.1145/1375761.1375762

REFERENCES

[1] Rex Hartson and Pardha Pyla. 2019. *The UX Book: Agile UX design for a quality user experience.* (2nd. ed.). Morgan Kaufman, Cambridge, MA.

[2] Youn-Kyung Lim, Erik Stolterman, and Josh Tenenberg. 2008. The anatomy of prototypes: Prototypes as filters, prototypes as manifestations of design ideas. *ACM Trans. Comput.-Hum. Interact.* 15, 2, Article 7 (July 2008), 27 pages. https://doi.org/10.1145/1375761.1375762

[3] Jakob Nielsen. 1989. Usability engineering at a discount. In Proceedings of the third international conference on human-computer interaction on Designing and using human-computer interfaces and knowledge based systems (2nd ed.), pp. 394-401.

[4] Yvonne Rogers, Jennifer Preece, and Helen Sharp. 2019. Interaction Design: Beyond Human-Computer Interaction (5th ed.). Wiley, Indianapolis, IN.

[5] Reinhard Sefelin, Manfred Tscheligi, and Verena Giller. 2003. Paper prototyping - what is it good for? a comparison of paper- and computer-based low-fidelity prototyping. *In CHI '03 Extended Abstracts on Human Factors in Computing Systems (CHI EA '03).* Association for Computing Machinery, New York, NY, USA, 778–779. https://doi.org/10.1145/765891.765986

[6] Carolyn Snyder. 2003. *Paper prototyping: the fast and easy way to design and refine user interfaces.* Morgan Kaufmann, San Diego, CA.

[7] Usability.gov. Prototyping. Retrieved from https://www.usability.gov/how-to-and-tools/methods/prototyping.html.

[8] Miriam Walker, Leila Takayama, and James A. Landay. 2002. High-Fidelity or Low-Fidelity, Paper or Computer? Choosing Attributes when Testing Web Prototypes. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *46*(5), 661–665. https://doi.org/10.1177/154193120204600513

A APPENDICES

A.1 Tool Handout

The handout is available in this link: bit.ly/educhi-proto-tool

TOOL

Prototyping Decisions

A prototype is a primitive version of something that will be iterated upon toward developing a final product. It is not the final product but an incomplete representation of some of its parts, allowing for faster development and iteration over design ideas. This means that the prototyping process requires making decisions about what and how to create the prototype in order to achieve its goal: to get the design of the prototype closer to the specification of the final product.

Prototyping decisions fall under two types:

1. Filtering Decisions

A prototype is **incomplete**, it does not include the full range of the product. This requires making decisions about what to include in the prototype, and what to leave out. A prototype's goal is to get feedback about certain aspects, therefore, the designer filters in the aspects they want people to pay attention to, and filters out aspects they don't want people to pay attention to.

2. Implementation Decisions

A prototype is a **representation** of the product, not the actual product itself. This requires making decisions about **how** to represent design ideas in the simplest and most **efficient** way. The design is likely to change in response to getting feedback on the prototype, so spending much time, effort, and funding on a prototype is a waste.

Filtering Decisions		
Prototyping Decision	**Decision Consideration**	**How to Decide**
Appearance	• The visual properties of the design, including colors, textures, sizes, fonts, shapes, and the proportional relationships among these elements. • In physical prototypes, this refers to the physical properties that can be sensed by touch. In speech-based prototypes this refers to the voice used including pitch, speed, loudness, etc.	If you want to explore different appearance choices or get feedback on them, include your appearance design choices in the prototype. Otherwise, use black & white and generic forms and shapes to represent the visual aspects of the design.
Content	The data and information presented and used in the prototype. The content can be realistic and come from real world data, be made up for the prototype only, or be absent, using placeholders (e.g., Lorem Ipsum text). Also consider the amount and type of content being presented (e.g., photos, text, numeric data).	The less realistic content being presented in the prototype, the more the designer can focus on usability dimensions alone. Adding more realistic content allows the user to orient to the prototype and relate to its real context of use. The tradeoff is that users will focus on evaluating the realism and relevance of the content in lieu of giving feedback on the UI design.
Features & functionality	Which functions and features are designed into the prototype. The prototype can be designed horizontally, to show the breadth of functions but not demonstrating the full interaction with them. It can also be designed vertically, choosing a small set of functions and representing them in-depth, showing the entire interaction flow from start to finish. Finally, a prototype can be T-shaped, showing both breadth of functions and demonstrating the features within a small set of functions.	Given the tasks identified by designers that the design should support, define which functions and features should be implemented into the prototype vertically, and which functions can be shown as placeholders, presenting them horizontally.

Filtering Decisions		
Prototyping Decision	**Decision Consideration**	**How to Decide**
Interactivity	The ways in which people interact with various parts of the prototype. This includes deciding how the user makes actions on the interface (buttons, input boxes, links, etc.), how the system responds to these actions (changing screens, information output, etc.) and the system response times.	More interactivity added to the prototype allows testing the interaction flow with usability metrics such as effectiveness and efficiency.

Implementation Decisions		
Prototyping Decision	**Decision Consideration**	**How to Decide**
Material	The medium used to create the prototype, including physical media (paper, wood, plastic) and tools for manipulating physical matters (scissors, pen, glue); software prototyping tools (Balsamiq, InVision, Sketch, Justinmind); fabrication tools (3D printer, laser cutter, arduino circuit boards).	Choose the material that allows you to represent design ideas in the prototype in the simplest, most efficient, and most cost-effective way.
Resolution	The level of details, sophistication, and accuracy of the prototype. Low resolution means rough, coarse, or simplified forms, and high resolution means adding detail and accurate representations that are closer to the final product in appearance, content, functionality, and interactivity. The resolution can also be hybrid, with some parts at a low resolution and others at a high resolution.	Higher resolution prototypes take more time and energy to create. Choose the lowest resolution needed for the current stage of the design development (adding resolution as the development progresses), the required speed of creation, and the degree of openness to change based on feedback.

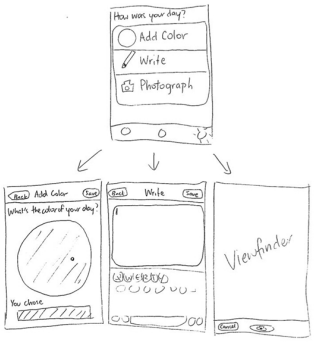
A.2 Poll Questions

The poll questions are available in this slide deck: bit.ly/educhi-proto-slides

Filtered in or out?

The **visual properties of fonts & colors** are:

1. Filtered in
2. Filtered out



GoSlow app early sketches

Answer: filtered out.

Filtered in or out?

The visual properties of fonts & colors are:

1. Filtered in
2. Filtered out

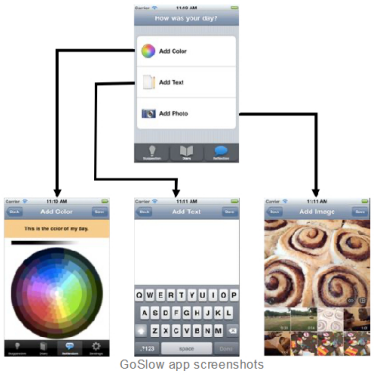
GoSlow app screenshots

Answer: filtered in.

Filtered in or out?

The functionality of "how was your day" is:

1. Filtered in
2. Filtered out



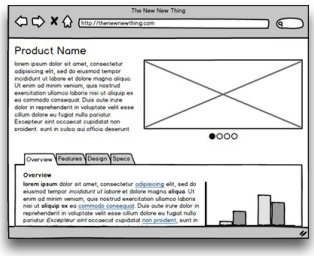
GoSlow app screenshots

Answer: filtered in.

Filtered in or out?

The text and image contents of this web page prototype are:

1. Filtered in
2. Filtered out



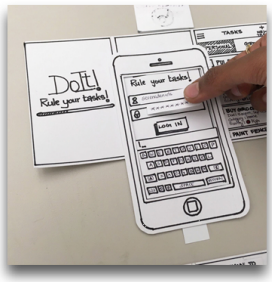
Some balsamiq prototype

Answer: filtered out.

Filtered in or out?

The interaction with the login screen in this paper prototype is:

1. Filtered in
2. Filtered out



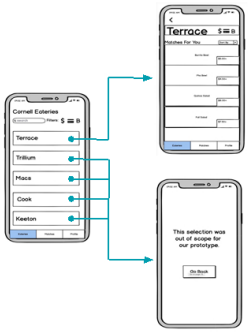
A paper prototype of app login

Answer: filtered in.

Filtered in or out?

The **functionality and content** of all the eateries options in this prototype are:

1. Filtered in
2. Filtered out

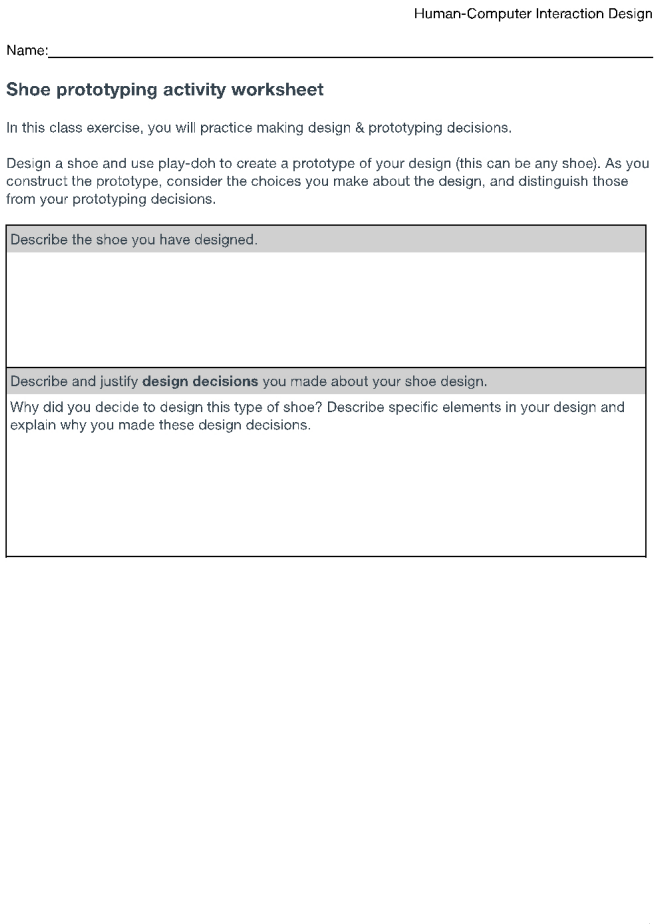


A balsamiq prototype of an app for finding eateries on campus

Answer: filtered out – this is an example of a T-shaped prototype, as some of the functionality is prototyped and some isn't.

A.3 Activity Worksheet

The worksheet is available in this link: bit.ly/educhi-proto-work



Human-Computer Interaction Design

Name:_____

Shoe prototyping activity worksheet

In this class exercise, you will practice making design & prototyping decisions.

Design a shoe and use play-doh to create a prototype of your design (this can be any shoe). As you construct the prototype, consider the choices you make about the design, and distinguish those from your prototyping decisions.

Describe the shoe you have designed.

Describe and justify **design decisions** you made about your shoe design.
Why did you decide to design this type of shoe? Describe specific elements in your design and explain why you made these design decisions.

1

Human-Computer Interaction Design

Describe and justify **prototyping decisions** you made related to **filtering**.

Describe any elements of your design that you decided to include in the prototype and justify why. For example, if your shoe design has laces, but your prototype doesn't allow actually tying the laces, then you filtered out this functionality.

Appearance: What visual and physical properties of the shoe did you choose to prototype? What visual and physical properties did you leave out?

Content: What data and information are presented in the prototype? What is left out?

Functionality: What functions and features are afforded in the prototype? What functions haven't been prototyped?

Interactivity: What interactivity did you choose to represent in the prototype? How does the shoe wearer interact with this prototype?

Describe and justify **prototyping decisions** you made related to **implementation**.

Describe your decisions about how to implement your prototype and justify why. Use the language of material and resolution. For example, for material you used play-doh, because this is what was defined for you in the class exercise.

Material: What medium was used to construct the prototype?

Resolution: What is the level of detail and accuracy of the different parts of the prototype?