An Analysis of Early Stage Prototypes Using Implementation, Look and Feel, and Role

by
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Abstract

Identifying the purpose of a prototype is central to making informed decisions about the kind of prototype to build. Houde and Hill (1997) propose a model for classifying prototypes according to their purpose and the design questions they answer. Since this model was created for user interaction design, it has never been applied to physical prototypes on a large scale or to a progression of prototypes through the product development cycle. Ten physical prototypes from an MIT mechanical engineering senior capstone design course are evaluated according to the Houde and Hill (1997) model. With only a few challenges, the model is found to be applicable to physical prototypes, providing insight into the nature of physical prototyping, the product development cycle, and MIT's senior design course. In the process, a notional relationship between the progression of the product development cycle and the number of design questions answered is proposed.

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1. Introduction

The creation and evaluation of prototypes is a fundamental part of the product design and development process. In the broadest sense, a prototype is a design tool that approximates at least one aspect of the product (Ulrich and Eppinger, 2008). However, the specific interpretation of what a prototype is can vary greatly among design disciplines. A physical foamcore model may serve as a prototype to an industrial designer, whereas a computer simulation is a commonly used prototype of an interaction designer. Regardless, the importance 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 and Hill, 1997).

Several models have been developed to classify prototypes based on their purpose and the design questions they answer. A triangle model created by Houde and Hill (1997) for classifying user interaction design prototypes presents a method of thinking about prototypes. Their model requires designers to focus on three questions: What role will the prototype play in a user's life? What should it look and feel like? And, how can it be made to work? These questions direct the designer to focus on the purpose of the prototype in order to make better decisions about the kind of prototype to build. Thinking about purpose also helps users provide more productive feedback (Houde and Hill, 1997).

The goal of this study is to apply the Houde and Hill (1997) triangle model to physical prototypes rather than user interaction prototypes. These physical prototypes were generated in an MIT mechanical engineering senior capstone design course. The triangle model was created with interaction design prototyping in mind and has only been used to analyze prototypes at single moments in time. Interaction design, by nature, does not generally employ physical prototypes. Prototyping modes such as computer simulations and storyboards will often suffice for the purposes of interaction design. This study aims to gain prototype design insight through the evaluation of the model's behavior over the product development cycle and in the context of physical prototypes.

2. Background

2.1 Prototype classification

A significant amount of thought has gone into the classification and analysis of prototypes. Prototypes are typically classified by their purpose and the design questions they answer. One model proposed by Ulrich and Eppinger (2008) classifies prototypes based on two dimensions. The first dimension asks whether the prototype is *physical* or *analytical.* As suggested, a physical prototype is a tangible artifact intended to represent some aspect of the product. Conversely, an analytical model is a conceptual, typically visual or mathematical, representation of an aspect of the product. The second dimension asks whether the prototype is *comprehensive* or *focused*. Comprehensive prototypes are fully operational, full-scale versions of the product. They incorporate and implement nearly all of the attributes of the final design. Focused prototypes, however, address one or only a few attributes of the product. Additionally, Ulrich and Eppinger (2008), identify prototypes by their design purpose, suggesting four possible options: learning, communication, integration, and milestones.

Ullman (2003) presents four classes of prototypes each distinguished by their function and stage in the product development cycle:

- In the initial stages of the design process, a *proof-of-concept* model is used to develop a better understanding for the design approach and to clarify the design objectives.
- Next, a *proof-of-product* prototype refines the physical geometry, components, and assemblies for production.
- Later, a *proof-of-process* prototype verifies the materials and manufacturing processes result in the desired product.
- Finally, a *proof-of-production* prototype, typically the result of a preproduction run, verifies the entire production process (Yang, 2005).

As shown in Figure 1, Houde and Hill (1997) propose a triangle model that aims to describe a prototype in terms of its purpose, rather than the prototype's incidental attributes.

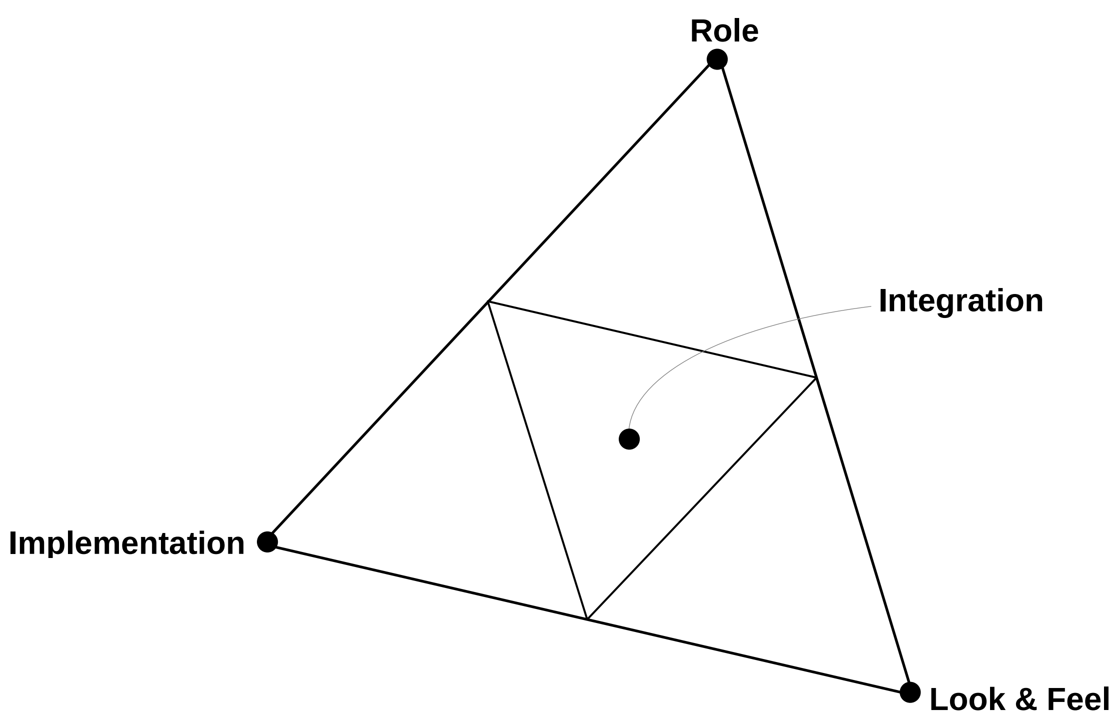

Figure 2-1: What Prototypes Prototype (Houde and Hill, 1997) triangle prototype classification model.

The vertices of the triangle represent three fundamental categories of design questions:

- *Role* refers to questions that address how the product will serve the user.
- *Look and feel* corresponds to questions that explore the sensory experience of the user. It investigates what the user will see, hear, or feel when interacting with the product.
- *Implementation* refers to questions about how the product will actually be made to work. It is concerned with the technical methods and components needed to perform the product's function.

Prototypes that serve a single purpose are confined to the vertices of the triangle. Often times, however, prototypes serve multiple purposes, thus falling along the edges of the triangle. The center region, denoted by *integration*, represents a combination of the three main types of design questions. Designers use integration prototypes to answer questions about the overall design and complete user experience.

Focusing on the purpose of the prototype allows designers to make better decisions about what tools to use and the kinds of prototypes to build. By establishing a clear purpose and expectation beforehand, prototypes can be used more effectively to think and communicate about design (Houde and Hill, 1997).

While the Ulrich and Eppinger (2008) and Ullman (2003) prototype classification models have been applied to physical products, the Houde and Hill (1997) model was originally created for user interaction design prototyping. As such, an application of the triangle model to a progression of physical prototypes on a large scale could provide another classification model for physical prototyping.

2.2 Additional prototype characterization

Prototypes may also be characterized by their level of detail or resemblance to the final product. In design, these qualities are described by the terms resolution and fidelity, respectively. In the context of the Houde and Hill (1997) model, it is important to note that the purpose of a prototype (role, look and feel, or implementation) can be characterized by any level of fidelity or resolution (Yang, 2005).

3. Methods

3.1 The context

This study analyzes the prototypes produced by a team of students in MIT's mechanical engineering senior capstone design course, Product Engineering Processes, in the Fall of 2010. In this class, students work in teams of 15-19 individuals with a $6,500 budget to design and build working alpha prototypes of new products over the course of twelve weeks. The course emphasizes the role of communication, teamwork, and creative thinking in design as well as quality engineering practices.

Each year the products are created around an overall theme. The theme for 2010 was “Food”. For the first six weeks, each team is divided into two groups. These groups work parallel to each other to generate three distinct product concepts by the end of the second week. After the presentation of the three ideas, each group selects two product ideas to pursue further. A sketch model for each concept is created and presented during the fourth week. Typically, the sketch model is a relatively simple physical model that can be prototyped quickly and inexpensively. Using feedback from the sketch model review, each group selects one concept to explore in more detail for the mock-up review during the sixth week. The mock-up review requires each group to develop a prototype that addresses and proposes a solution to the key challenges of the design concept. Upon the conclusion of the mock-up phase, the two groups of each team unite and select one mock-up direction to work on for the remainder of the course. Over the next four weeks, the teams work to refine their product concept for the technical review. The purpose of the technical review is to provide an opportunity for teams to demonstrate the functionality of their final prototypes and to identify and prioritize the critical design adjustments for the final presentation. The technical review prototype is intended to be a fully functional representation of the product. The last milestone of the course is the final presentation which occurs during the twelfth week. A polished version of the technical review prototype is created and presented to an audience of over one thousand attendees including instructors, course sponsors, product developers, business entrepreneurs, and other guests of both technical and non-technical backgrounds.

In a nutshell, eight different teams individually select six ideas from the hundreds generated during brainstorming exercises. From the remaining six ideas, four become sketch models. Of the four sketch models, two become mock-ups. Finally, each team selects one mock-up concept to pursue for the remainder of the course, creating a prototype for both the technical review and final presentation.

3.2 Evaluating the prototypes

The work in this paper is based on the analysis of ten prototypes from the Silver team. Although only eight prototype cases were expected: four sketch models, two mock-ups, a technical review prototype, and a final presentation prototype, the Silver team produced two additional sketch model prototypes.

Design information about each prototype was collected using a prototype questionnaire developed by MIT graduate student Anders Häggman for MIT’s graduate engineering systems division Product Design and Development course. The questionnaire can be found in Appendix A. The questionnaire addresses items such as design purpose, scope, cost, and lessons learned.

As a member of the Silver team, I was able to obtain much of the needed prototype information from my personal experiences. However, I required the assistance of my teammates to complete the information on the sketch model and mock-up prototypes from the first six weeks of the course, as the Silver team was split into two independent groups during that time. In order to collect this information, I conducted interviews with my teammates both in person and through e-mail. The interview questions followed the format of Häggman's prototype questionnaire.

It is important to note that while the prototypes are examined retrospectively, the information gathered is reliably accurate for the purposes of this study. The information provided by myself and others has been cross-checked on separate occasions and was found to be congruent.

From the questionnaire data, the main design question, purpose, and degree of fidelity and resolution were identified for each case. Each prototype was classified according to the triangle model categories: role, look and feel, and implementation.

4. Results and discussion

The Silver team's ten prototypes from the 2010 MIT mechanical engineering senior capstone design course, Product Engineering Processes, are applied to the Houde and Hill (1997) triangle prototype model. Below, each prototype is first evaluated according to the central design question it answers. In some cases, additional design questions are identified due to the complexity of the prototype. Second, the purpose of each prototype is determined and explained according to the triangle model classification. Finally, the level of fidelity and resolution are noted for each case. Figure 4-11, then depicts the location of all ten prototypes on the triangle.

1. Biodiesel Process Sketch Model
    - Design Question: Is it possible to make biodiesel at home in small batches and what are the challenges of the task, specifically for fully automating the conversion process?
    - Role and Implementation – This prototype focused on role as it attempted to determine if and how a home biodiesel batch process is useful to a user. It also addressed implementation as it identified the technical challenges of the conversion process in order to give insight for scaling down the process.
    - Low Fidelity – This prototype did not resemble a real, automated biodiesel system.
    - Low Resolution – This prototype was created with minimal detail.

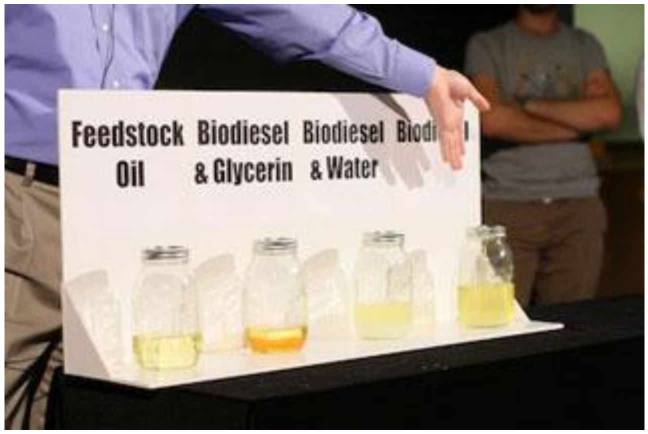

Figure 4-1: Sketch model prototype of the biodiesel conversion process

2. Biodiesel Sensor Sketch Model
    - Design Question: Is it possible to distinguish two distinct density liquids autonomously at minimal cost?
    - Implementation – This prototype purely tested the method of identifying the boundary at which two liquids of different densities (water and glycerin) meet in a separated mixture.
    - Low Fidelity – This prototype was a simple proof-of-concept model. It did not incorporate the sensor into an actual valve system.
    - Low Resolution – This prototype was created with minimal detail.

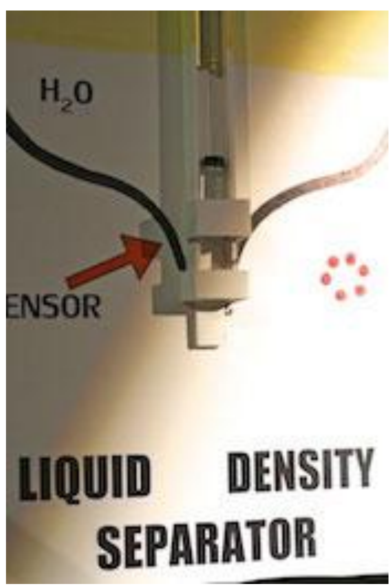

Figure 4-2: Sketch model prototype of the biodiesel liquid density separator – an LED sensor and receiver mounted in a foamcore channel with two vials of distinct liquids (one of water and one of biodiesel) passing through the sensor field.

3. Tourné-Do Blade Sketch Model
    - Design Question: Is using a single blade on a track an effective way to tourné a potato?
    - Implementation - This prototype tested the ability of a single blade to cut a tourné potato.
    - Low Fidelity
    - Low Resolution

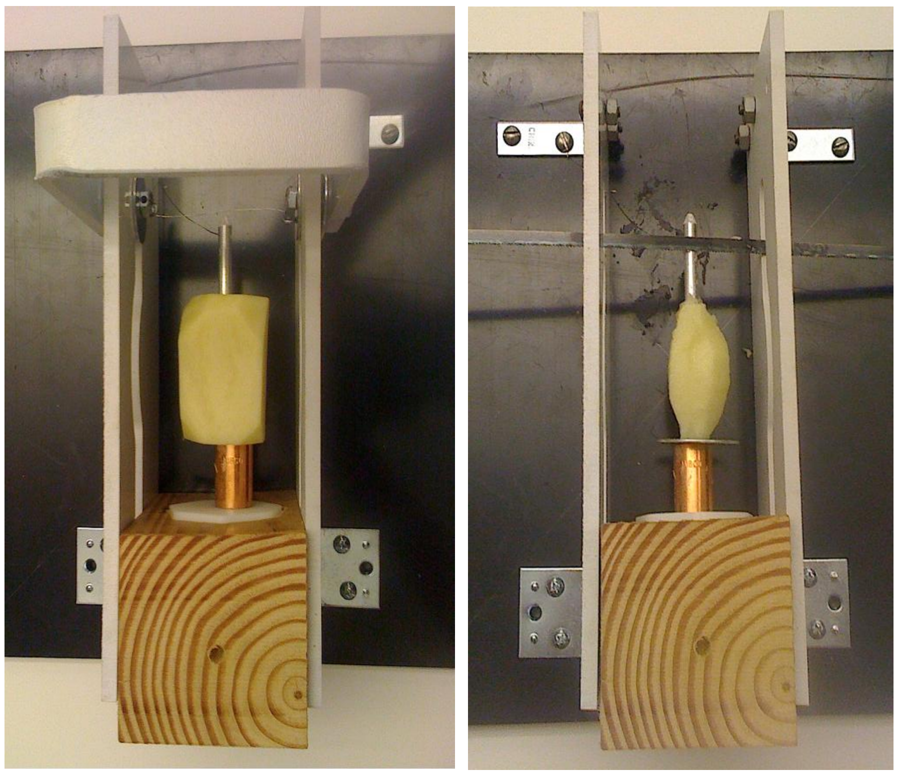

Figure 4-3: Tourné-Do Blade sketch model prototype - a single thin blade on a track profiling a tourné cut. It is hand-powered and uses a single pin to skewer and hold the pre-stamped stock vegetable.

4. Tourné-Do Iris SM
    - Design Question: Could a seven blade iris diaphragm be used to tourné a potato?
    - Implementation - This prototype evaluated the mechanical feasibility of using an iris diaphragm mechanism to cut a tourné potato.
    - Low Fidelity
    - Low Resolution

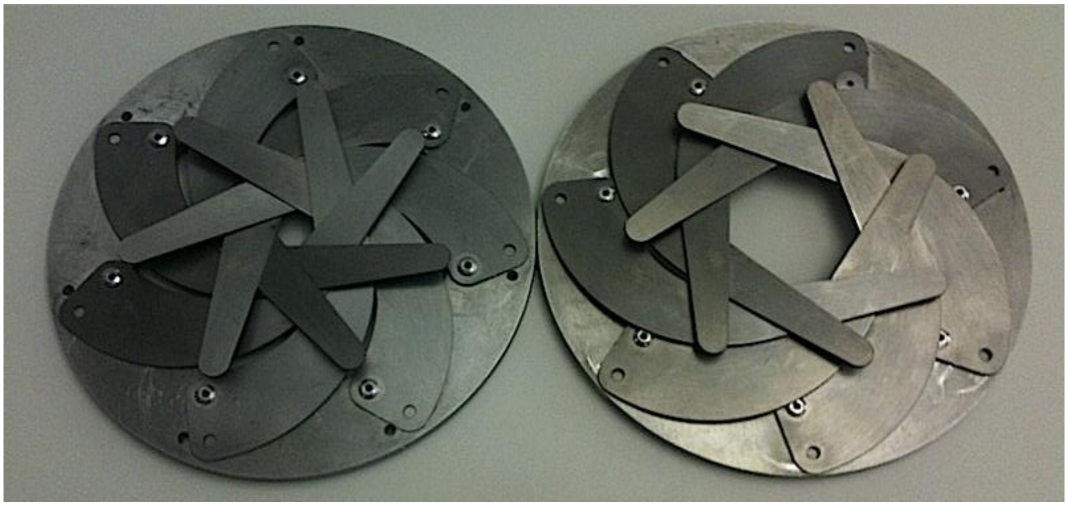

Figure 4-4: Tourné-Do Iris sketch model prototype - a seven blade iris diaphragm tourné cutting mechanism.

5. Wilbur Wake Up Sketch Model
    - Design Question: Is it possible to turn on toaster heating elements using a digital signal from a low switching voltage microcontroller?
    - Implementation - This prototype demonstrated the use of a digital signal for triggering the activation of toaster heating elements for the purpose of eventually cooking bacon when triggered by an alarm clock.
    - Low Fidelity
    - Low Resolution

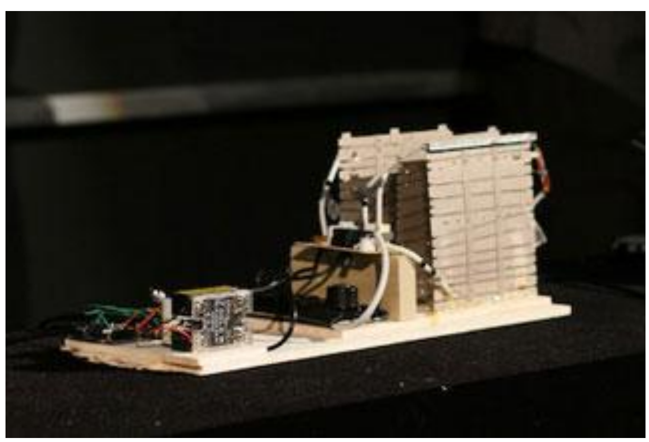

Figure 4-5: Wilbur Wake Up sketch model prototype - demonstrates the activation of toaster heating elements using digital signal triggering.

6. CoasterBot Sketch Model
    - Design Question: Is there a market for a bar top drink delivering robot? Would bartenders like this product?
        - Additional Questions: How would this product work in a real environment? What are the technical and physical challenges? How would a bartender and patrons interact with the CoasterBot? Would bars like to use this product?
    - Integration: Look & Feel, Role, Implementation – While this prototype was able to answer a wide variety of questions. The main goal of the prototype focused on look & feel. It was made to be small and cute, and to convey the concept of a CoasterBot. At this initial stage, it was most important to know if this product concept had a market. Role was also considered, but it was not emphasized as the robot was not programmed to locate a patron, respond to customers, etc. Some user interaction feedback was gained, but not to a large extent. Regardless, the prototype was able to generate some feedback on what the product should do and how users might interact with it. Implementation was also addressed, but to a lesser degree. Remote controlling the prototype overlooked the actual coding and circuitry issues that would be central to the product.
    - Medium Fidelity – This prototype included the character, mechanical components, and some user interaction that would be very similar to a final product, but it did not account for navigation techniques or address the demands of a bar top environment.
    - Medium-high Resolution – This prototype included a significant amount of detail including LED decoration, integrated battery power, and realistic mechanical components.

Figure 4-6: CoasterBot sketch model prototype - a remote controlled coaster shaped robot for delivering drinks to patrons at a bar. It is laser cut out of acrylic.

7. Tourné-Do Longitudinal Mock-up
    - Design Question: What are the technical challenges of tourné-ing a potato using a rotary motion wire cutter mechanism?
    - Implementation - This prototype evaluated the use of the rotary wire cutting mechanism for cutting a tourné potato. It aimed to verify the design concept and to identify the mechanical flaws of the current design.
    - Low-medium Fidelity – While this prototype improved upon the stock vegetable loading and cutting techniques of the sketch model, it still had a long way to go to meet the acceptable size, repeatability, speed, and precision of a final product.
    - Medium Resolution – This prototype included an adjustable tension wire cutting mechanism, rotary motion along a mathematically calculated tourné profile, and a slide-out vegetable loading platform. This was a significant increase in detail from the sketch model predecessor.

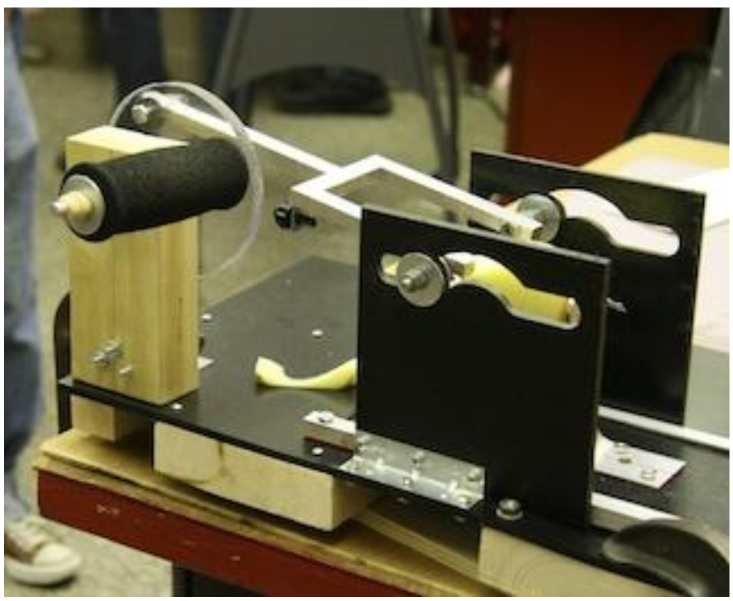

Figure 4-7: Tourné-Do Longitudinal mock-up prototype – uses a wire cutting mechanism with hand-powered rotary motion and two pins to secure the pre-stamped stocked vegetable at both ends.

8. CoasterBot Mock-up
    - Design Question: How will the navigation sensors behave in a realistic environment? What are the sensing challenges of autonomously navigating a cluttered bar top? Is wall following navigation the best approach?
    - Implementation, Look & Feel – This prototype mainly focused on implementation as it sought to reveal the challenges of autonomous bar top navigation. The team concentrated primarily on the sensors, circuitry, battery life, and microcontroller code. Unlike the remote controlled sketch model, the mock-up design used an Arduino microcontroller for completely autonomous navigation. Look & feel had a very minor focus since the physical design changed to a 3D printed chassis with a customizable laser cut lid.

- Medium-high Fidelity – This prototype nearly represented a final product except for waterproofing measures, refined aesthetics, and a much needed printed circuit board.
- Medium-high Resolution – This prototype included a significant amount of detail by integrating the components and circuitry into and 3D printed custom chassis.

Figure 4-8: CoasterBot mock-up prototype – autonomously controlled by an Arduino microcontroller and IR sensors through wall following navigation. The chassis is 3D printed instead of laser cut.

9. SushiBot Technical Review
    - Design Question: Can SushiBot meet the demands of a restaurant environment and provide a novel user experience?
        - Additional Questions: How will the user interact with SushiBot? Would people enjoy this product as an alternative to conveyor belt sushi restaurants? What is the best restaurant layout for SushiBot? How will multiple SushiBots behave in a realistic environment? Does the user feel happy and excited by SushiBot?
    - Integration: Role, Implementation, Look & Feel – The focus on this prototype was mainly shared between implementation and role. It was important to see how users would interact with SushiBot. Since the design of SushiBot welcomes user interaction, it was important to see what physical demands SushiBot would face and what the user expected. The prototype also identified sensing and navigational challenges that arise in a busy restaurant environment. Line following ability, travel speed, and load capacity were specifically targeted. Look & feel was also important. The design team wanted to see how the product affected the customers' emotions and what physical changes could be made to enhance the user experience. Multiple chassis were manufactured to gain feedback on SushiBot's style and character.
    - High Fidelity
    - High Resolution

Figure 4-9: SushiBot technical review prototype – autonomously controlled by an Arduino microcontroller and IR sensors through line following navigation. SushiBot has a 3D printed chassis, a custom PCB, and plate detection capability with several response dances.

10. Noribo Final Presentation
    - Design Question: Can Noribo meet the demands of a restaurant environment and provide a novel user experience?
        - Additional Questions: Would people enjoy this as an alternative to conveyor belt sushi restaurants? How will multiple Noribos behave in a realistic environment? Does the user feel happy and excited by Noribo? Is Noribo a viable product and how can it be improved?
    - Integration: Look & Feel, Role, Implementation– While many of the questions from the technical review were still valid, this prototype was made to present the product and convince investors, clients, and customers of its potential and novelty. Implementation, Role, and Look & Feel improvements were made since the previous iteration, but additional feedback in all areas was expected and welcomed. Because role and implementation attributes were considered to be close to their final forms and Noribo would be in its most realistic environment to date, look & feel was given slightly more attention.
    - High Fidelity – This prototype closely resembles a final product
    - High Resolution – This prototype has a high level of detail.

Figure 4-10: Noribo final presentation prototype – the next generation of SushiBot from the technical review. Noribo was manufactured in the same way and with the same components as its predecessor, but hardware and aesthetic improvements were made.

1. Biodiesel Process Sketch Model
2. Biodiesel Sensor Sketch Model
3. Tourné-Do Blade Sketch Model
4. Tourné-Do Iris Sketch Model
5. Wilbur Wake Up Sketch Model
6. CoasterBot Sketch Model
7. Tourné-Do Longitudinal Mock-up
8. CoasterBot Mock-up
9. SushiBot Technical Review
10. Noribo Final Presentation

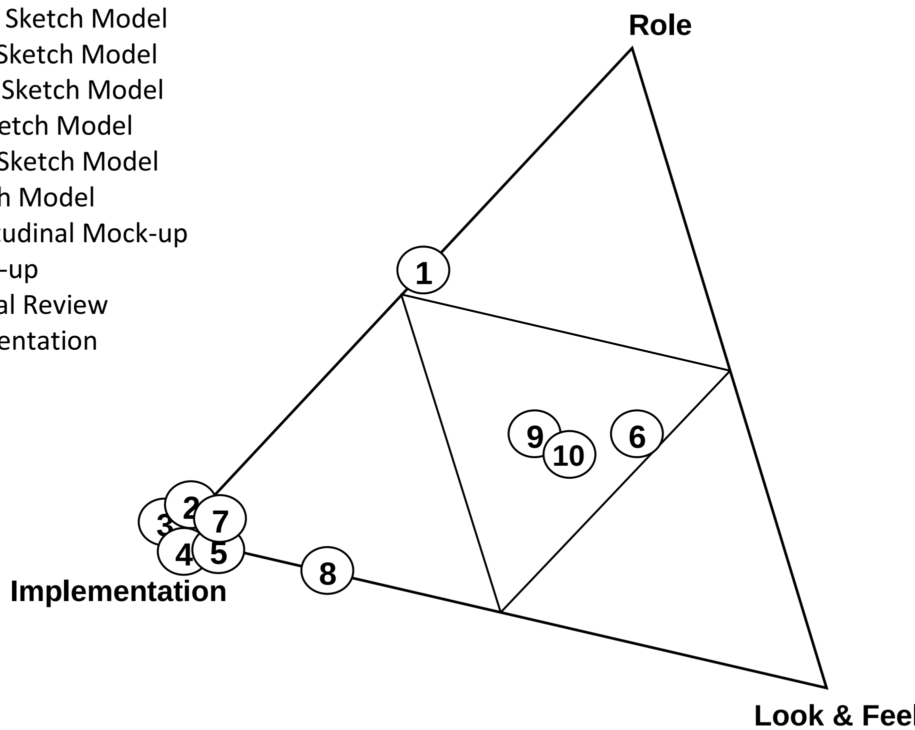

Figure 4-11: The Houde and Hill (1997) triangle model showing the classification of all ten prototypes.

As shown in Figure 4-11, each prototype could be applied to the Houde and Hill (1997) triangle model. From the model, several initial observations can be made. First, the Tourné-Do Longitudinal mock-up and every sketch model prototype, except the Biodiesel Process prototype, fall solely on the implementation vertex. This suggests that designers, particularly students in MIT's senior design course, focus strongly on technical feasibility during the initial stages of the product development cycle. Additionally, the model offers valuable insight into the evolution of a prototype over time. To better visualize the progression of a prototype through the product development cycle, Figure 4-12 below displays the CoasterBot sketch model and its subsequent iterations.

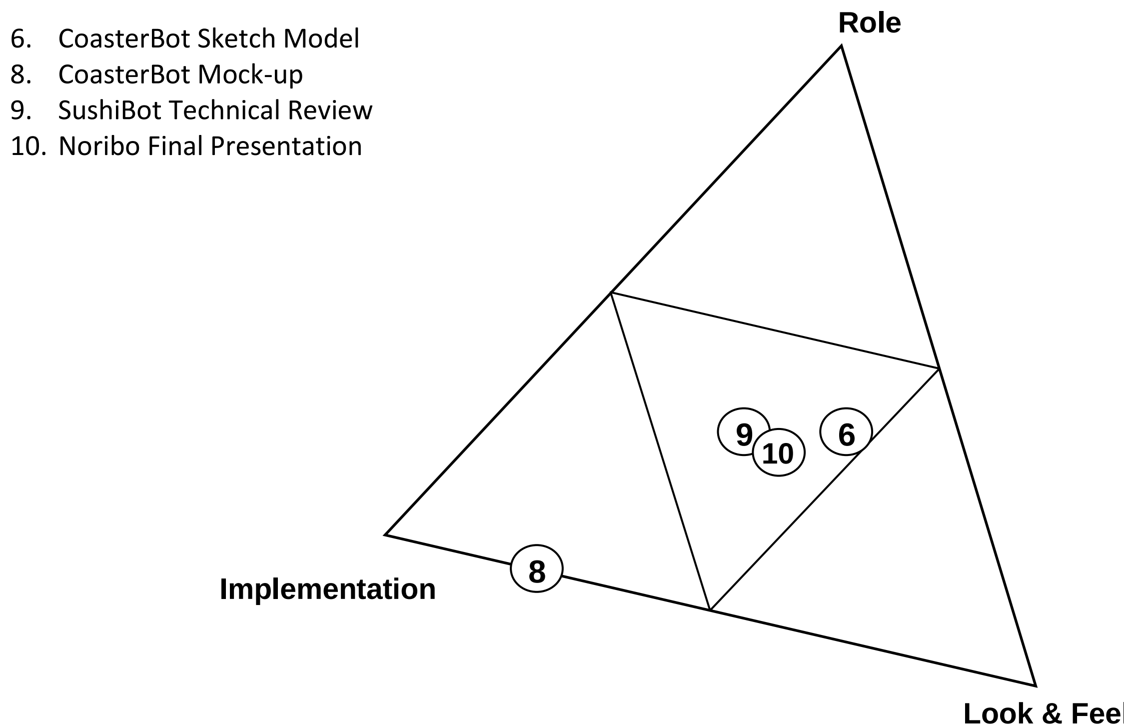

Figure 4-12: Houde and Hill (1997) triangle model showing the product cycle progression of CoasterBot to Noribo.

As shown in Figure 4-12, the development of CoasterBot to Noribo begins and ends in the integration region with a short time spent focusing on implementation and slightly on look and feel during the mock-up phase. Additionally, the SushiBot technical review prototype, located at the center of the integration region, is more uniformly integrated across all the three purposes than its successor, Noribo. These results challenge the notion that a prototype will grow more integrated as the product development cycle progresses. Rather, it suggests that while integration may be more likely to appear later in the product cycle, the purpose of a prototype is not necessarily tied to a specific stage of development.

Not only does the visual result of the triangle model offer valuable insight, but the process and analysis of its application reveal notable relationships between prototype development and time as well. Through the process of identifying the central design questions, a list of questions posed and lessons learned was formed for each prototype. Consider the development of CoasterBot. From the mock-up phase to the SushiBot technical review, each prototype continued to answer more questions than the previous model. However, from SushiBot to Noribo, the number of design questions answered remained virtually stagnant as indicated by the fact that the purpose of both prototypes were nearly identical. Figure 4-13 below illustrates a notional relationship between design questions answered and time.

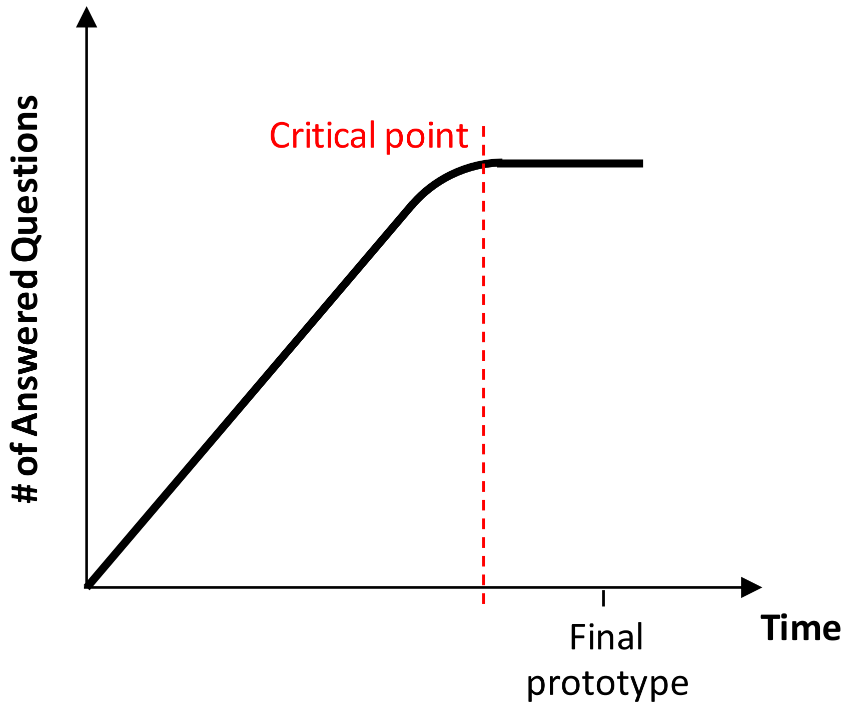

Figure 4-13: Notional relationship between the number of design questions answered and time.

According to this study, it is probable that as the product cycle progresses, the number of design questions answered continually increases up to a critical point whereupon the number of answered questions plateaus. This critical point may be characterized by an impending final prototype deadline. In the context of MIT's senior design course, this plateau can be attributed to the approaching final review milestone deadline. At such a late stage in the product development cycle, implementing changes becomes more involved, expensive, and time consuming. For this reason, changes to non-critical design attributes were ignored from the technical review to the final review. It is important to note that this behavior is in no way considered applicable to the development of all physical products. Rather, without further investigation, this theory may be only reasonably applied to projects similar in nature to MIT's mechanical engineering senior design course.

Continuing with the same theme, a relationship between the product development cycle and the level of prototype fidelity and resolution can be highlighted from this study's analysis. Figure 4-14 below, graphically summarizes the results noted at the beginning of this chapter.

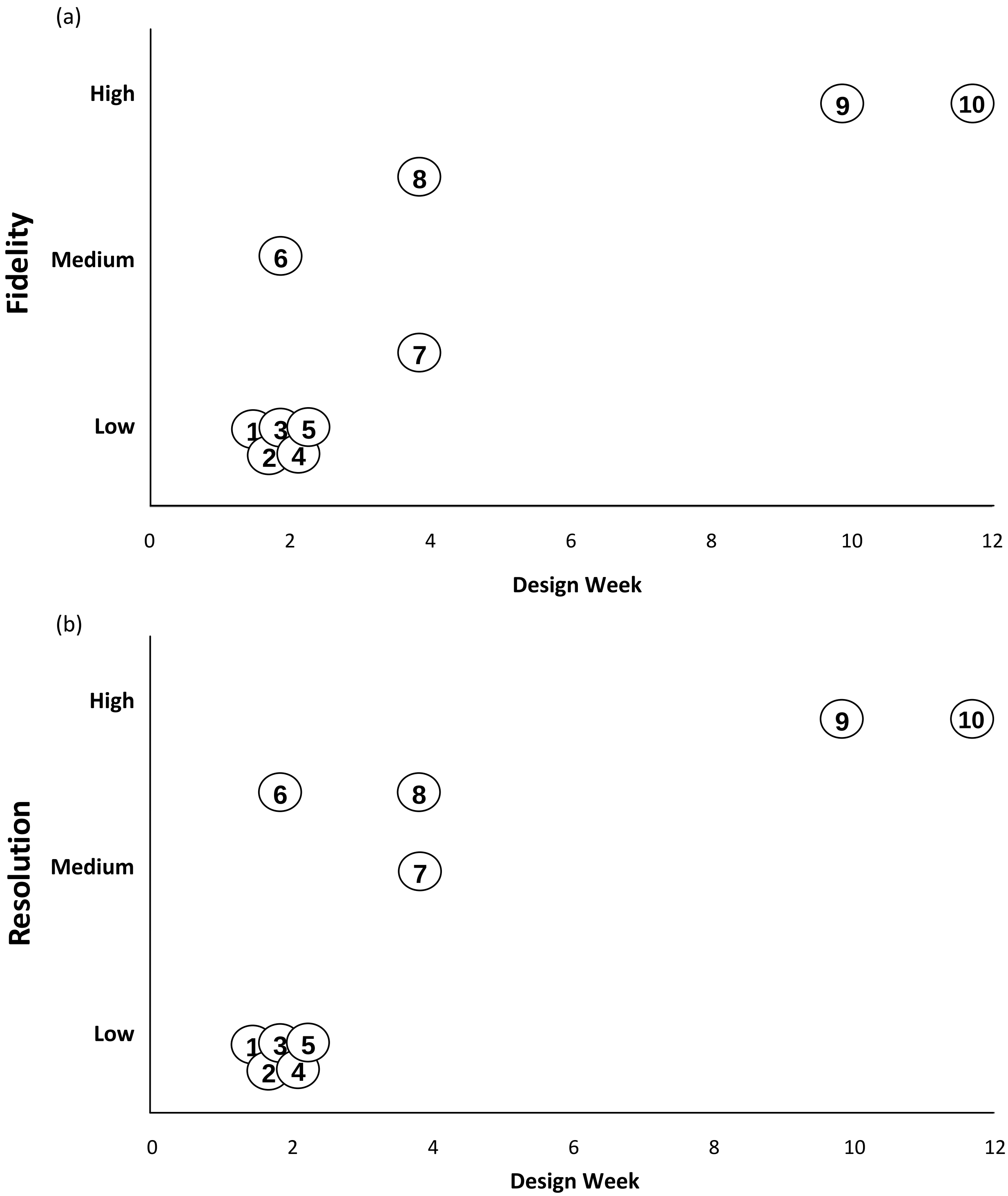

Figure 4-14: graphs (a) and (b) show the relationship between level of fidelity and time, the relationship between level of resolution and time, respectively

Prototypes 6, 8, 9, and 10 represent the progression of CoasterBot to Noribo and prototypes 3 and 7 represent the progression of Tourné-Do. As shown in Figure 4-14b, the level of resolution never decreases from one prototype to the next. At times, the level of resolution may remain the same, but overall, there is a tendency to increase throughout the development cycle. Similarly, the level of fidelity increases as the product cycle progresses. This behavior, however, may be only characteristic of MIT's senior design course. Houde and Hill (1997) suggest that the levels of fidelity and resolution can vary at random across prototype iterations.

Aside from what was learned from the actual visual display of the triangle model and the process of analyzing the prototype information, the challenges of applying the model remain to be discussed. Each prototype was successfully assigned a place on the Houde and Hill (1997) triangle model. In general, the model was extremely easy to apply to the physical prototypes created in MIT's senior design course. However, it was slightly challenging to isolate design questions centered on role for a few of the sample prototypes. This challenge can most likely be attributed to the discovery that role and look and feel questions are very closely related when considering physical prototypes. For example, the SushiBot technical review prototype had a strong focus on how users would interact with the product. Due to the interactive nature of SushiBot, the designers felt that the appearance and personality of the prototype had a significant influence on how the customers would use the product. Depending on the personality of SushiBot, the user would be more or less inclined to pick up or play with the robot. In this way, design questions of role and look and feel were interdependent. It is possible that this complication is relevant to physical models, but not the interaction design prototypes originally used with the Houde and Hill (1997) triangle model.

Houde and Hill (1997) use a clearly defined design purpose as a tool for selecting the kind of prototype to build. Since they recommend identifying the purpose prior to building the prototype, this study classifies each prototype according to its intended design purpose rather than the consequential lessons learned. Because the prototype analysis was performed retrospectively, identifying the intended design question for each was one of the more difficult tasks of this study. As the prototypes became more integrated, the number of design questions was found to increase significantly. While some prototypes answered many questions, not all of these questions were intentionally posed or specifically stressed. The SushiBot technical review prototype illustrates this phenomenon. As an integration prototype, SushiBot aimed to answer a wide variety of questions in all three purpose categories, however, not all of these questions were initially considered significant. For example, the question asking if SushiBot invokes feelings of happiness or excitement only became important after building the prototype and receiving user feedback. Had this study been performed in conjunction with the senior design course, this observation may not have arisen. Nonetheless, it is an interesting finding for the triangle model because it suggests that there is a difference between classifying prototypes based on their intended purpose and their unintended consequence. Furthermore, it proves that a prototype can elicit valuable, unanticipated feedback.

5. Conclusions and future work

This study explored the possibility of applying the Houde and Hill (1997) triangle prototype classification model to physical products. In the process, a few challenges were identified. The first was the seemingly inherent difficulty of distinguishing design questions of role from look and feel for physical prototypes. The second was the challenge of retrospectively determining the intended design purpose of a prototype. While the latter situations were challenging, they did not prevent the successful application of the triangle model to the 2010 Silver team's physical prototypes from MIT's mechanical engineering senior design capstone course. Rather, they provided insight into the nature of physical prototyping, MIT's senior design course, and opportunities for future investigation.

After accomplishing the successful application of the model, further analysis was performed and additional observations were discovered about the model and the product development cycle. Prior to this study, the triangle model had not been applied to a progression of prototypes through the product development cycle. As anticipated, numerous notable findings resulted. The first was that early stage prototypes tend to focus on questions of implementation. The second was that the purpose of a prototype is not necessarily tied to a specific stage in the product development process. Although integrated prototypes tend to appear later in the cycle, they may appear early on as well.

Other lessons were learned, however, their significance is less concrete as they are highly dependent on the nature of MIT's senior design course and the specific sample cases studied. The first is the suggestion that the number of questions answered by physical prototypes will increase until time and cost demands mount, whereupon the number of answered questions will level off. The second is that the levels of fidelity and resolution will tend to increase as the product cycle progresses. While these observations are valuable, they require further investigation on a larger scale.

Overall, the lessons learned from this study can be used by designers and users to think more effectively about physical prototyping. The triangle model helps an audience provide useful, focused feedback on a product and forces designers to focus on the purpose of a prototype, allowing them to make better decisions about what kinds of prototypes to build (Houde and Hill, 1997).

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Appendix A – Prototype questionnaire

Version:14 **ESD.40 | PROTOTYPE REPORT | Spring 2011** Part A

Instructions.

A. **Complete a "prototype report" for every prototype that members of your team make.**

B. The definition of "prototype" is very wide, and includes everything from taping two empty toilet paper rolls together to prototype binoculars, to more detailed prototypes. If you assemble prototypes from off-the-shelf components, include those as well. Taking an existing product, and modifying it slightly counts as a prototype also. Anything you build or assemble should be included. If you are not sure, include it!

C. If your end product is software, please consider distinctly different versions of the software as separate prototypes.

D. Take *at least* one picture of your prototype. Put all pictures of the same prototype into a folder, and name the folder as follows <Team name>_<Date submitted (mmddyy)>. Example: Team01_031411.jpg. Upload the picture folder and prototype report into you Stellar folder. Write the name of the folder in the space provided below.

E. For each faculty consulting session (3/30 or 4/4, and 4/20 or 4/25), please include copies of your recent prototype questionnaires as an appendix. Please also save an electronic version into your team folder on Stellar (rename it so that you don't save over any of your previous prototype reports). It is suggested that you fill in the prototype report as soon as possible after making the prototype, before you forget any details.

Background Information.

Name	Team	Filename for folder with photographs

Building the Prototype.

1. Approximately when was the prototype made? between __MM__ /__DD__ / 2011 – __MM__ /__DD__ / 2011

2. Please describe your prototype in a few sentences.

3. Please try to recall *when* and *where* the idea for this current prototype was conceived?
   When (approximate date):__________ Where were you?__________
   What were you doing:__________
   If something special happened, that gave you the idea, what?__________

4. What is the scope of the prototype?
   • Small Feature • Part • Mechanism / Sub-assembly • Whole product

5. Please estimate total actual building time for prototype: ____ Days ____ Hours ____ Minutes

6. Approximately, how much money did you spend on the prototype? $______________

7. What were the main reasons the prototype was made? (you may select several)
   • **Evaluation** of the current design (testing the design's function, role or form) "function"
   • **Communication** within the team / clarify something to other team-members "make it real"
   • **Feedback** (from outside the team, such as customer or end-user) "feedback"
   • Check-point (course **requirement**) "because we had to"
   • **Creativity** (eg. you wanted to play around with a vague idea) "thinking tool"

   • **Other**, please specify__________

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8. Did you hand sketch the idea before building it?

- **Yes**
  (you may select several)
  - to getter a better sense of how different parts are **placed** with respect to each other
  - to getter a better sense of what the **overall** shape will be
  - I was just **doodling** / drawing a rough idea I had thought of / recording my ideas
  - I wanted to **explain** my idea to other team-members
  - **Other** ____________________

  Why did you decide to build a prototype after sketching the idea?:
  ____
  ____

- **No**
  Why not: ____________________

9. Did you CAD the idea before building it?

- **Yes**
  (you may select several)
  - to check that the parts **fit** (that they don't hit each other)
  - to make **measurements** on parts or the whole assembly (or to check how large parts *can* be)
  - to run **analysis** / simulation (CFD, FEM/FEA, etc.)
  - to show / **communicate** the idea to someone (at a distance, electronically)
  - **Other** ____________________

  Why was CAD not sufficient? (why did you also build the prototype?):
  ____
  ____

- **No**
  Why not: ____________________

Your responses to this section (questions 10-14, <u>including pictures of your prototype</u>) may be shared with the rest of the class through stellar, so that teams may learn from each other.

Lessons Learned.

10. How do you feel about the future of the current prototype?

I think we should...

- ...stay with this one (test it further)
- ...change it a little (eg. add a button or change the wheels)
- ...change a lot (build a new prototype, in the same general design direction)
- ...take a new direction entirely (change the whole design direction)

Please feel free to elaborate why?____

11. What did you learn from the prototype (questions you were looking answers for)?

12. Please also rate what you learned.

- We learned nearly everything we expected to
- We learned some of what we expected to
- We learned nearly none of what we expected to

13. Did you learn anything that you didn't expect to?

14. How significant were the unexpected lessons learned (question 13)?

- Very significant
- Moderately significant
- Only slightly / not at all significant

Feedback on the Questionnaire. (Optional)

I did not understand question(s):_______________
Question ______ is repetitive / too long.

I like ____
I wish ____

Other free form comments :