Reflections on Data Collection during Toy Prototype Development in a Design Studio Course

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ABSTRACT

During product development, it is common to elicit feedback from various stakeholders, especially during prototype testing. This iterative "build and test" practice enables designers to reframe problem spaces, define stakeholder needs, and implement design changes. Toy prototypes are unique in that they require input from children (often the end-users), parents/guardians (often the consumer), and experts in the field. In a unique client-sponsored product innovation course, 10 cross-functional design teams collaborated to research, ideate, prototype, and evaluate toy prototypes across a span of 16 weeks through three main checkpoints. With the first and second checkpoints of prototyping activities completed, this ongoing study outlines the data collection methods and learnings of the complexities in engaging design students and stakeholders, including children as the end users, in the design process. The study has implications for stakeholder engagement in design pedagogy and ways for researchers to explore the interactions between designers and stakeholders in the classroom.

CCS CONCEPTS

• **Human-centered computing** → Interaction design; Interaction design process and methods; Contextual design.

KEYWORDS

Toy Prototypes, Children, Product Development, Data Collection

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1 INTRODUCTION

Design involves the balance and prioritization of multiple stakeholder voices while managing and implementing design changes in an iterative prototyping process [1, 2]. Adding to this complexity are the various perspectives, ideas, and feedback of stakeholders that impact design decisions [3, 4]. In toy product development, children are typically the primary end-users. This means that children are more involved in the design process, specifically when taking a human- or user-centered design approach [5, 6]. Other key stakeholders such as parents (usually the consumer/customer), industry experts (such as in manufacturing, material selection, or the product domain, like musical instruments), and clients may offer their perspectives and feedback to improve prototypes.

This work-in-progress study reports the learnings and challenges of data collection procedures in toy prototype development, as part of a larger study around engagement with multi-stakeholders in design. We first introduce some background and then provide a review of the research methodologies, emphasizing the coordination and complexity of data collection during a semester-long university course. The study has implications for both design and research practices, seeking to incorporate stakeholder voices (children ages 2-10 years, parents, and industry experts) in the design process while navigating through the challenges of participant recruitment, coordination, time constraints, and usability testing preparations.

2 RELATED WORK

2.1 Children as Key Stakeholders

Historically, children's voices have been left out in toy product development where designers relied on child development experts and parents to provide insights into how children interact with a design [7, 8]. However, with children's increasing role in toy product development, they are quickly filling various roles such as design partners, informants, testers, and users in participatory design [5, 9]. Codner and Lauff (2023) tested low-fidelity prototypes with children to understand their feedback, focusing on three interaction principles: signifiers, affordances, and mental models. They discovered that the lack of intention to use signifiers and mental models in the prototype models affected the types of feedback received from children [10]. This highlights the challenges in fully understanding the cognitive capabilities and mental models of children, including children's shorter attention spans, limited cognitive abilities to understand abstract concepts, and the ability to articulate [8, 11, 12]. This requires designers to understand how children think, behave, perceive, or interact with toy prototypes during testing [9, 13–15].

2.2 Balancing Stakeholder Voices in Design

The balancing act of design teams navigating conflicting stakeholder feedback and deciding on which feedback to implement in future prototype iterations emerges as an opportunity in the literature [1, 16–18]. There remains a lack of understanding of why certain stakeholder feedback is prioritized over others, and how designers incorporate children's feedback. With the inclusion of children as key stakeholders amongst other relevant stakeholders, designers are expected to develop and build toys that create a friendly and playful user experience for children while targeting business needs and consumer demands [19, 20]. Past studies engage children's

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Figure 1: Examples of Bubble Toy Prototypes at Checkpoint 1 Created by Design Teams

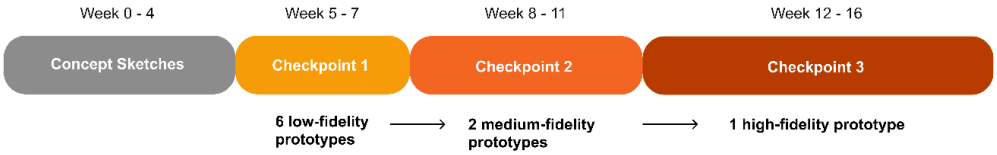


Figure 2: Timeline of Prototype Checkpoints over 16 Weeks in Semester-Long Design Course

voices through participatory design in various fields using children's drawings, play behaviors and toy prototype interactions to inform a better understanding of children's perspectives [9, 21–23]. However, the limited understanding of children's cognitive abilities and mental models in toy product development poses a challenge in understanding children's needs and effectively incorporating their feedback in design [16, 18, 20, 24].

3 METHODOLOGY

This study is situated in a semester-long (16 weeks) design course at a large, public research university in the United States. In January-May 2024, data was collected from a four-credit interdisciplinary design studio course where a client sponsored the project. The class brings together students from several disciplines, including engineering, product design, and business to create a new product. This year's course project aims to develop innovative bubble toys; students can pick the context, such as for parties, summertime, entertainment, and/or everyday use. Examples of bubble toy prototypes created at checkpoint 1 in the course are shown in Figure 1.

Through the unique class structure, students engage in an iterative prototyping process and test with multiple stakeholders across three prototyping checkpoints throughout the semester (see course timeline in Figure 2). After the initial stage of concept ideation, each team creates six "sketch models' or low-fidelity prototypes. The second checkpoint refines and iterates on those six sketch models into two "works-like" medium-fidelity models based on stakeholder feedback. The third and last checkpoint takes one of the two prototypes and converges into a higher fidelity model that highlights the "works-like" and "looks-like" aspects of the final concept. The goal is to design fun and engaging bubble toys that are desirable, viable, and feasible.

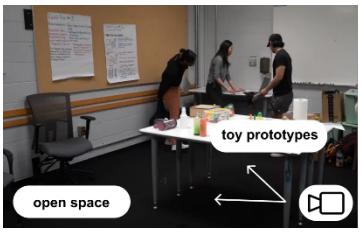
3.1 Participants

There are 62 students enrolled in the course, of which 55 students (53% female, 47% male) provided consent and opted into the research study. There are 10 teams, and each team has six or seven members. Students come from various backgrounds including product design (n=30), mechanical engineering (n=9), industrial systems (n=2), computer science (n=7), individual studies in art (n=3), agriculture (n=1), marketing/communications (n=2), retail merchandising (n=2), apparel design (n=1), and graphic design (n=5). This is a required course for all product design majors and product design minors, and it fulfills an elective requirement for other degrees. Participation in this research study did not require additional work outside of class, but voluntary participation and consent were required to collect students' design work, prototype testing results, presentations, and recordings of prototype testing per the Institutional Review Board (IRB).

Stakeholder participation is also important so that we can examine the interactions between designers and stakeholders during prototyping activities. The key stakeholders are children (end-users), parents (customers), industry experts, and the client. The intended age range for children is 2-10 years, but this varies depending on the design direction each team decides to pursue. 13 parents and 15 children along with 10 industry experts participated in the first and second checkpoints. In the third and last checkpoint, four parents and four children along with four industry experts are recruited for prototype testing. A sample of 44 stakeholder participants is expected by the end of the semester. Stakeholder participants were allowed to repeatedly test at each checkpoint, but this is optional. The IRB approved the study before any data collection occurred. Consent was obtained from each participant (students and stakeholders) before prototype testing.

3.2 Data Collection and Analysis

The study combines multiple methods of data collection: surveys, observations, presentations, recordings of play and usability testing, and design documents/artifacts. Semi-structured, ad hoc interviews may be administered since design is an iterative process, and more information may be needed to clarify and explore more perspectives [25]. For data analysis, open coding using affinity diagramming and thematic analysis will be used to dissect qualitative data [26]. Quantitative data from Likert scales and multiple-choice questions will be analyzed using statistical software to compare and infer relationships between each checkpoint.



(a)


(b)


(c)

Figure 3: (a) Layout of testing room; Design student testing toy prototype with two children in Room 1 (b) and Room 2 (c)

3.3 Data Collection Procedures

As a work-in-progress research study, we are currently part-way through data collection. At the time of this paper's submission, we engaged in data collection for the first and second prototype checkpoints (see Figure 2). Due to the complexity of data collection in this design course, we include a detailed description of all the data collected and lessons learned thus far. Design teams were also informed of best practices to conduct testing and perform observations, especially when testing with children where both verbal and nonverbal cues are crucial to understanding children's feedback.

3.3.1 Play and Usability Testing. Children, parents, and industry experts were recruited through email, word of mouth, flyers, and shared postings in childcare centers. We compensated stakeholders with a gift card of $20/hour for individuals and $30/hour for groups (parent and child together). Each stakeholder group tested with at least two design teams for about 25 minutes each, totaling about an hour of prototype testing. For example, after parents and children test with one design team in Room 1, they will switch rooms and test with the second design team in Room 2 while the industry expert moves from Room 2 to Room 1. The research team led the planning for prototype testing and participant recruitment, while design teams built the toy prototypes and conducted the prototype testing sessions. We defined two research roles to streamline the process of testing: (a) facilitators, responsible for being more of a "fly-on-the-wall" and recording and observing each testing session from the edge of the testing room, and (b) coordinators, who guided stakeholders to the testing rooms and completed the check-in, IRB consent form, and compensation processes. Three separate, private rooms were reserved on campus: two rooms for testing and one room as the waiting room for stakeholders. A video camera was set up in the corner of each room with tables, chairs, and an open "play" space (see Figure 3a). All participants were asked to arrive 15 minutes earlier to ensure that consent forms were signed, and questions were answered. Each testing session was recorded by the designated researcher facilitator in the room (see Figures 3b and 3c).

In the first checkpoint, 10 design teams tested a total of 60 toy prototypes with six children, six parents, and five industry experts. Two design teams tested simultaneously to enable testing of all design teams within four hours, which was the allotted class time. For the second checkpoint, design teams tested a total of 20 toy prototypes with nine children, seven parents, and five industry experts. Teams will test 10 toy prototypes in the third checkpoint.

3.3.2 Reflective Prototyping Surveys. After each testing session, design teams completed a stakeholder feedback survey and a post-test survey. Both surveys took about 15 minutes. The stakeholder feedback survey consisted of twelve questions with a mix of open-response, multiple choice, Likert scale, and selection questions. The included questions elicited designers' perceptions on stakeholder feedback and can help to identify future approaches to iterating the toy prototypes (i.e., *Which categories did you receive feedback in regarding the prototype? What nonverbal feedback did you receive? What were you hoping to learn from this testing session?*). The post-test survey enabled design students to reflect on their ideas and learnings, consisting of seven short questions with open-response and multiple-choice questions. The questions were asked to understand if testing with stakeholder feedback impacted individual designers' perceptions of their prototypes in the next iteration (i.e., *Before prototype testing, what were the top 2 concepts in your team you believe will move forward? After prototype testing, what are the top 2 concepts in your team you believe will move forward?*). Both surveys were created and administered through Google Forms and inspired by previous studies in prototyping and testing with children [16].

Teams were required to complete the stakeholder feedback survey for each prototype and stakeholder they tested with. For the first checkpoint, each design team completed this survey 18 times (6 prototype models x 3 stakeholder groups). For the second checkpoint, design teams completed this survey 6 times (2 models x 3 stakeholder groups). Teams will only complete the form 3 times for the third and final checkpoint (1 model x 3 stakeholder groups). As for the post-test survey, each student in their respective design team will complete on their own to assess individual learnings. In the first checkpoint, we had a total of 187 responses for the stakeholder feedback survey from 10 design teams and 52 valid responses from students in the post-test survey. In the second checkpoint, we had a total of 67 responses for the stakeholder feedback survey from 10 design teams and 49 valid responses from students in the post-test survey. Survey data were uploaded and stored securely in a Google Drive. Team information was de-identified using fruit pseudocode (i.e., Apple Team, Blueberry Team, Lemon Team, etc.).

3.3.3 Design Checkpoint Presentations. As part of the class, the presentations for each checkpoint were recorded for the teams' and instructor's reference. The first checkpoint presentation had a unique format where groups of stakeholders (client and industry experts) rotated to each team's table for the presentation. Each team rotated and showcased six toy prototypes for 10 minutes,

leaving 2-4 minutes for questions in the first checkpoint. In the second checkpoint, teams presented their two prototype models for 10 minutes to the client, industry experts, and the entire class . For the last checkpoint, teams will present their final prototype in a theatrical and playful 5-minute presentation to the client, industry experts, parents, children, and the community. Steps are taken to prevent identifiable participant information such as using participant codes or pseudo-names.

3.3.4 Design Documentation. We also collect all design documentation from teams, such as prototype images, text documents, Gantt charts, CAD models, and other relevant information about the design process of the prototypes. These documents and artifacts are vital to understanding the thought processes, design iterations, and decision-making processes of each design team. The course is structured such that each team has a shared Google Drive folder with limited access to only the design and research team.

4 LESSONS LEARNED

This work-in-progress study outlines the learnings from data collection in a university design course focused on designing and building toy prototypes. We encountered challenges in our current data collection that can inform future data collection. For example, the ages of children recruited for prototype testing did not always align with what design teams were looking for specifically which may influence the types of feedback, questions, and approaches that each team took. We also observed that teams may improve their interactions with stakeholders over time from the first checkpoint to the next as they engage in stakeholder interactions more and learn how to improve stakeholder communication. This may impact the quality and types of feedback received in future checkpoints.

For prototype testing, we realized that children require more time, attention, and flexibility, which hinders the rigid and controlled nature of the pre-scheduled testing sessions. The time constraint of about an hour of testing for each team with about 25-30 minutes with each stakeholder group was the biggest limiting factor since it conflicted with children's early bedtimes. This timing was chosen due to the nature of the course and scheduling testing sessions during a longer studio time (4 hours on Thursday evenings). Due to this, we had parents and children test together and explicitly recruited parents who were available to attend testing on the designated date and time. We also allowed parents to bring more than one child to the testing session since toy prototypes are best played collaboratively. Although we provided incentives for participation such as compensation, snacks, and parking validation, we noticed how this did not necessarily alleviate the challenges of participant recruitment. Moving forward, we will continue to recruit participants early, ensure we have backups in case of last-minute cancellations, and explore different schedules to see if this changes recruitment.

The lack of testing consistency with stakeholders across the teams may influence the quality, frequency, and categories of feedback that design teams receive. Although best practices and guidelines for testing with children were provided with a class lecture, we observed that design teams were not able to apply these skills and strategies directly without much training or practice. Similarly, design documentation is required for the class, but there is no documentation standard which may impact the consistency of the data. We also noticed that if we do not provide guidelines on the types of files and naming conventions, it can be difficult to decipher the documentation uploaded to each Google Drive folder. Overall, the process of creating spaces for participatory design of both designers and stakeholders (children, parents, and industry experts) has proven to be challenging and complex, requiring intentional considerations of best testing practices, design documentation methods, and coordination efforts in a design studio course.

5 FUTURE WORK

As we move forward, we will continue data collection for prototype checkpoint three, and then synthesize the data to answer our overarching research questions:

- How is stakeholder feedback translated into the next iteration of prototypes?
- How does feedback differ between various stakeholders (children, parents, experts, and clients) for prototype testing at various stages of the design process?
- How does the fidelity of a prototype affect the types of design changes implemented?

Together, we aim to streamline the process of designer-stakeholder interactions with toy prototypes by developing a broader and more in-depth understanding of children's play, toy prototype evolution, and the types of stakeholder feedback based on the fidelity of the prototype.

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SELECTION AND PARTICIPATION OF CHILDREN

Selection and participation of children is crucial to our study especially since children are key stakeholders in toy prototype development. Although participatory and co-design efforts were increasingly made to include children and other key stakeholders in design conversations, there remains a lack of understanding of how exactly designers engage children in usability tests to elicit relevant feedback as intended. With the understanding that children are a unique group of individuals that may serve distinct roles in toy product development such as users, testers, design partners, and more, it is no surprise that being intentional in engaging children in the design process is vital. In this study, children aged 2-10 years old were recruited to engage in play and usability testing with design teams as part of a collaborative effort to bring children's voices to a university design studio course. Design teams conducted these prototype testing sessions with children through observations and discussions on usability issues related to play and interaction with the toy prototypes. Children were given time to play and openly share feedback through both verbal and nonverbal communication, indirectly collaborating with design teams on future toy prototype iterations. Therefore, the initial steps taken in this study to select and include children's participation in a design studio course can hopefully share insights about the complexity of integrating stakeholder engagement with design pedagogy and enabling designers and children to collaborate.

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