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Co-Evolving Towards Evil Design Outcomes: Mapping Problem and Solution Process Moves

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Abstract: Creative outcomes require designers to continuously frame the problem space and generate solutions, resulting in the co-evolution of problem and solution. Little work has addressed the value dimensions of design activity with regard to this co-evolutionary process and the role of the designer in acting upon specific and value-laden framings and/or solutions. In this paper, we identify how triads of student designers from user experience (UX) and industrial engineering (IE) disciplines frame the problem space and generate solutions, foregrounding the ethical character of their judgments in response to an ethically-nuanced design task. Using sequence analysis to analyze the lab protocol data, we describe the frequency and interconnectedness of process moves that lead the design team towards unethical outcomes. Based on our findings, we call for additional attention to ethical dimensions of problem-solution co-evolution, and identify key interaction patterns among designers that lead towards unethical outcomes.

Keywords: co-evolution; ethics; problem framing; sequence analysis; decision-making

1. Introduction

Creative outcomes require the cognitive ability of designers to continuously frame the problem space and generate solutions, resulting in what Dorst and Cross (2001) have called a “co-evolution of problem–solution,” building upon a similar concept of co-evolution from Maher, Poon, and Boulanger (1996). While the framing activities of designers have been studied from numerous perspectives, little work has addressed the value dimensions of design activity with regard to this co-evolutionary process and the role of designers in selecting or choosing to act upon specific and value-laden framings and/or solutions.

In this paper, our primary contribution is to describe the co-evolution of solution and problem space through a value-focused lens, identifying process moves among designers that represent potential value inscriptions taking place as a set of inter- and intra-designer patterns. Through the identification and articulation of these patterns, we move beyond

co-evolution as a cognitive or pragmatic representation of design activity alone, and identify the value relationships inherent and foundational to these process moves—both within a designer's own cognition and as distributed among the frame negotiation of multiple designers—further elaborating the ethical nature of design work.

2. Related Work

2.1 Co-Evolution and Design Cognition

The cognitive work that designers engage in has been the subject of substantial prior scholarship, beginning with an effort to describe and elucidate the "black box" of design in the 1970s (Jones, 1970), and then later with attempts to describe characteristic behaviors of designers and design complexity as part of a "second generation design methods" (H. Rittel, 1984). While we cannot recount the entire movement from a focus on design as a rational enterprise to design as contextually and socially situated, we wish to call attention to specific features of design cognition that have particular impact on the framing of our present study. The notions of problem and solution spaces that are investigated through various forms of framing have been substantial components of design scholarship since the 1970s (H. W. J. Rittel & Webber, 1973; D. A. Schön, 1990). These efforts identified the social and cognitive complexity of design work, and the need for the designer to "frame a problematic design situation: set its boundaries, select particular things and relations for attention, and impose on the situation a coherence that guides subsequent moves" (Donald A. Schön, 1988). Many scholars—Kees Dorst in particular—have built upon this notion of problem framing, noting the role of framing in managing design complexity and identifying paradoxes that might be productively addressed (Dorst, 2015).

Building upon notions of problem framing and the generation of potential solution spaces, Maher, Poon, and Boulanger (1996) proposed that the concept of *co-evolution* acted as a set of evolutionary processes whereby problem spaces continuously interacted with potentially related solution spaces, and that design activity could be productively viewed as an set of explorative and co-evolutionary processes. Building on this work, Dorst and Cross (2001) validated this concept through a protocol study, defining the co-evolutionary processes of expert designers. Since the early 2000s, numerous scholars have further extended the concept of co-evolution, describing interactive characteristics that emerge in design teams (Hey, Joyce, & Beckman, 2007; McDonnell, 2018), identifying transitions in relation to methods and goals (Storm, van Maanen, & Gonçalves, 2019), and clarifying the moment of creative emergence (Dorst, 2019).

In this paper, we built upon these investigations of co-evolution with a particular focus on the trajectory of design behavior, highlighting the ways in which co-evolutionary moves can be considered as value-laden, as also argued by Lloyd (2009) as he parsed the role of ethics in design thinking and in the unfolding of design process. We do this by tracking co-evolutionary design moves as they are sequentially shaped by the priorities of individual

designers, leading to outcomes which could be considered hostile to human values. While acknowledging that the notion of co-evolution is a well-established design concept, used in this paper as our theoretical framework to define our unit of analysis, the novelty of our work lies in overlaying ethics as an important component of co-evolution.

2.2 Ethics and Values in Design

Ethical engagement has long been considered as a core aspect of design behavior, as design itself is committed to shaping new futures through the creation of the "not-yet-existing" (Nelson & Stolterman, 2012). Ken Friedman described this commitment as follows: "To serve human beings, outstanding professional designers must master an art of human engagement based on ethics and on care. Design education must foster such skills and knowledge." (2012, p. 150). However, studies on design cognition have infrequently focused on the value commitments that designers take on in their work, even as value-focused methods have risen in prominence (e.g., B. Friedman & Hendry, 2019). In this sense, we wish to foreground notions of ethics and values as a key dimension of design activity, expanding upon two sets of related disciplinary literature: 1) professional ethics; and 2) notions of inscription from Science and Technology Studies (STS).

The professional ethics literature in design and technology contexts has been dominated by work in engineering ethics (e.g., Bucciarelli, 2008; Harris, Pritchard, Rabins, James, & Englehardt, 2013; Herkert, 2000), at least in part due to licensure and accreditation requirements. While the topic has been raised in a design education context (e.g., Buwert, 2018; Findeli, 2001), these instances have been somewhat rare, and lacking the substantial integration into educational programs that has been true in engineering and technology education. In our own work, we have built on revised codes of ethics in human-computer interaction and computer science contexts (Brinkman, Gotterbarn, Miller, & Wolf, 2016) to identify opportunities for engagement with ethics and value-related dimensions of design behavior (Gray, Toombs, Light, & Vines, 2018). In prior work, we have investigated how designers implement "dark patterns" into digital and physical systems, subverting user value in exchange for shareholder value (Gray, Kou, Battles, Hoggatt, & Toombs, 2018). This integration of manipulative or coercive intentions has also led us to identify how designers convert their value-centered or manipulative intentions into concrete solutions and support them through rationale (Chivukula, Gray, & Brier, 2019). In this paper, we seek to build on this prior work to identify the interactivity of this ethical exchange, using co-evolutionary processes to describe where and how evil intentions are being introduced and built upon in the design process.

Research in STS has engaged substantially in the ethical character of design activity and the value-laden nature of designed outcomes. While a variety of methods have been created to highlight and support the values that designers incorporate into their work, these methods have failed to reach broad adoption by designers, and it is unclear how the routines that are supported by these methods relate to specific design activities. Value-Sensitive Design (VSD) is perhaps the most prominent methodological framework (e.g., Friedman & Hendry, 2019),

but Albrechtslund (2007) has critiqued earlier iterations of this framework for attending more to "backwards-looking" design without enough focus on "forward-looking" design potential as an outgrowth of the multistability of design outcomes. Other STS voices, such as Verbeek (2006, 2010) have also highlighted the ways in which designers inscribe values in their design work, which we have expanded on as an expression of the designer's character in prior work (Gray & Boling, 2016). These accounts of inscription—whereby values are intentionally or unintentionally embedded into the physical and interactional potential of a designed artifact—also raise the issue of what (and whose) values should be considered. More recent expressions of these values, arising from a range of critical feminist and social justice perspectives (Costanza-Chock, 2018; Dombrowski, Harmon, & Fox, 2016; Manders-Huits, 2011), encourage attention to not only a pre-determined set of human values (e.g., B. Friedman & Kahn, 2003), but also to discovering values that may have relevance for specific groups or underserved and disempowered populations. In this paper, we build upon these critical traditions to describe what values designers are aware of while they engage in design work, and how this inscription process is supported by co-evolutionary design moves.

3. Method

We used lab protocol approach (Gero & McNeill, 1998) to capture dialogue and interactions among designers that provide detail to describe their value orientations, tensions, and sensitivity while addressing an ethically-nuanced design task. This method allowed us to replicate portions of real-world UX practice settings and capture ethically-related process moves of the designers as they ideated, discussed, and built solutions for a given problem space. We conducted four one-hour lab protocol sessions with three student designers each, and video-recorded all participant interactions. We observed the designers exchanging ideas and framing the design space to solve the given task during these sessions. A thematic and sequence analysis of these interactions helped us describe the co-evolution of problem and solution during decision making by an individual as well as among the designers. Taking this approach, we answer the following research questions:

1. What design moves do participants engage in that have an ethical character?
2. What patterns of co-evolution of problem solution and rationale are present, and how do these patterns relate to ethical dimensions of decision making?

3.1 Participants

We conducted four protocol sessions with three participants each. In total, we recruited twelve student designers from UX (User Experience) and IE (Industrial Engineering) programs, at both the undergraduate and graduate levels at a large Midwestern university in the USA. We recruited these participants through e-mails sent through departmental listservs and professional networks to create a stratified sample based on academic classification and degree objective. To participate in our study, the students had to have previously either worked on design-related projects, have taken a design-related course,

or worked as a practitioner or intern in a design firm. Two sessions (Group 1 and 4) had a mixture of UX and IE students and two sessions (Group 2 and 3) had UX or IE students only. For this study, we do not seek to analyze the impacts of cross-disciplinary interactions between the UX and IE designers.

3.2 Study Design

Each protocol session was one hour in duration, including: an introduction (5 mins), design activity (45 mins), presentation to the researchers (5 mins), and follow-up questions to the participants based on the observations (5 mins). The substance and framing of the design tasks were based on prior interviews and conversations with practitioners, with the goal of replicating the bluntness and calls for explicit persuasion that are typical in real world stakeholder requests. Additionally, it is well-established in captology (Atkinson,2006) and in Fogg's (2009) persuasive strategies that one approach to persuasion and nudging is to manipulate users without their knowledge. This literature was used to motivate the task framing and learn more about the designer behaviors in these contexts. Additionally, this task and protocol design was one of three protocol studies we conducted where the design tasks moved from persuasion for altruistic purposes towards more typical and problematically capitalistic goals. The group of designers was asked to address a task for Amazon, with the request to collect more user data to improve Alexa's experience. The design task stated:

> "*We would like you to help us manipulate the user into giving up privacy permissions for their Amazon Alexa. We are hoping to gain the ability to listen in on all of the users' conversations and use this data to help advertisers better personalize the experience of using Amazon product.*"

Participants were provided with current wireframes of Alexa's mobile application, including the home page, settings, and permissions pages. The participants were asked to iterate on these wireframes or completely change the user interactions in order to address the design goal. Alongside these materials, they were given a flyer that consisted of basic interaction design principles (Norman, 2013) and persuasive principles (Fogg, 2009) using neutral language. The design principles included visibility, feedback, affordance, mapping, constraint, consistency, learnability and usability. The persuasive principles included persistence, reduction, suggestion, prominence, tunneling, and exclusivity. The participants were provided with sketching material, Post-Its, whiteboards, and markers for sketching and discussion purposes.

3.3 Data Collection

During the protocol session, the participants were video and audio recorded using cameras from above and the front. The front angle captured the entire conversation, expressions, and movement of the participants during the session and the top angle recorded sketching actions and exchanging of the participants in more detail. The recordings were fully transcribed and verified by the researchers. We used the interaction analysis method (Jordan

& Henderson, 1995) to clean these transcripts, adding pseudonyms to our participants, indicating "inaudible" instances and adding time stamps to each speech act, defined for this study as a single conversational turn. Pseudonyms were used in the form P0nA, B, and C, where n (=1,2,3,4) for the four sessions and the uppercase letter represents each participant in a single session. Session 4 was excluded from this study due to low audio quality.

3.4 Data Analysis

We conducted data analysis in three iterative rounds. Initially, we started by open coding (Saldana, 2015) the different design moves taken by the participants in each group based on their design decisions. We define *design moves* through their communicative speech acts as decision making instances which take the design action forward. For example, a design move could include a designer proposing a solution to achieve the goal given in the design task. Conducting a thematic analysis to axially organize the open codes (Braun & Clarke, 2006), the design moves we identified include: solutions, problem or rationale, agreement, disagreement, and design production. This process was conducted by one graduate student, who was trained in qualitative research through prior projects and coursework. The themes were cross checked with the principal investigator to finalize and create a codebook. We then created a codebook (Table 1) with the final categories of design moves that would structure a sequence analysis.

Table 1 Thematic codes of Design Moves

Theme	**Description**	**Example**
Solution	Design moves proposing an idea or concept to solve the given design task	"*...you could bundle that and be like, "Access your microphone and contacts."*
Problem Definition	Design moves framing the design space to generate or support their solutions or build scenarios.	"*So they have no other choice, but to put that and access everything. 'Cause if you keep giving people options, they'll start thinking more and more about it, like something, their privacy being taken away.*"
Agreement or Disagreement	Bidding moves where the designer is agreeing or disagreeing to the conversation, ideas or process during discussion.	Agreement: "*Yeah*" or "*Mm- hmm (affirmative)*" Disagreement: "*Nah. I would say not a pop up again.*"
Implementation	Design moves planning the interface design for the proposed solution, user task flow in a real scenario or visual design of the solution	"*if you click this, then this [button] comes up. But if you click this [button], the disclaimer will come up.*"

Research / Design Logistics	Speech acts that were not directly related to decision making and look at only logistics such as time, sketching practices, division of labor or planning of the logistics. **Note:** We removed all these speech acts from our analysis and numerical results provided in the findings section.	"*Yeah. I mean, why wouldn't you just draw up on black, on white board.*"

In the second round of analysis, each speech act was coded using this codebook. We then conducted two different types of analysis to describe the sequence and interactions among the various design moves, particularly focusing on capturing the temporal progression of these activities in relation to co-evolution behaviors. First, we identified the design moves used by the three designers in each group in a holistic manner, limiting our analysis to the 45 min design task portion of the transcripts. We calculated the total number of speech acts under each theme as well as the number of speech acts per each participant under each theme. These descriptive statistics informed our understanding of each designer's role in decision making (generating solutions or framing the space through rationales) as well as the patterns of communication among the designers (agreeing, disagreeing and implementing the decisions). These quantitative results, while useful, did not provide adequate detail regarding how the designers built off of each other's decision making, which prompted us to conduct a sequence analysis.

The final phase of analysis included a sequence analysis, building on concepts from interaction analysis. This type of analysis focused on how the three participants exchanged and interacted with each other in the context of design moves. To begin this process, we initially chunked various design moves in each session to divide the 45 min session into multiple *vignettes*. These design moves were indicated by conversational turns from one topic to another or a conversation to an action. For example, a vignette while discussing a certain solution was separated from a shift to discussing another solution or the design act of sketching ideas. These vignettes became our new unit of analysis. Within each vignette, we identified patterns of interactions, as shown in Figure 1.

4. Findings

Based on the analysis described above, we present our findings in two related sections. First, we present a holistic view of the co-evolution of problem and solution in each protocol group among the triad of designers. Second, we present the observed patterns of co-evolution of problem and solution, describing the function of each pattern in foregrounding ethical decision making, and providing two vignettes from one protocol session to illustrate these patterns.

4.1 Evidence of Co-evolution

In this section, we provide a holistic view of how the co-evolution of problem and solution occurred through the number of speech acts. Descriptive statistics of the number of speech acts for each design move—solution, rationale, agreement, disagreement and implementation—for each designer through the first three protocol sessions are presented in Table 2. The percentages are calculated over the total number of speech acts in the session (excluding speech acts related to research/ design logistics). Solutions were generally focused on explicit and concrete design outcomes, while statements of the problem space were generally foregrounded through rationale for pursuing a specific problem frame or set of constraints. Therefore, we use the term "problem definition" through the remainder of the findings section to refer to the team's working definition of the design problem being addressed.

Table 2 Descriptive Statistics of coded design moves

Group	Designer	Solution	Problem Definition	Agreement	Disagreement	Implementation	Total # (per participant)	Total # (in session)
1	P01A	**21** (7.34 %)	**41** (14.34 %)	**17** (5.94%)	**5** (1.75%)	**20** (6.99 %)	**105**(36.71%)	286
	P01B	**12** (4.2%)	**18** (6.29%)	**1** (0.35%)	**2** (0.7%)	**15** (5.24%)	**55**(19.23%)	
	P01C	**27** (9.44%)	**47** (16.43%)	**27** (9.44%)	**2** (0.7%)	**20** (6.99%)	**126**(44.06%)	
2	P02A	**12** (2.99%)	**36** (8.96%)	**13** (3.23%)	**1** (0.25%)	**35** (8.71%)	**96** (23.88%)	402
	P02B	**14** (3.48%)	**24** (5.97%)	**60** (14.93%)	0	**47** (11.69%)	**146**(36.32%)	
	P02C	**19** (4.73%)	**47** (11.69%)	**39** (9.7%)	**1** (.25%)	**53** (13.18%)	**160**(39.8%)	
3	P03A	**16** (3.46%)	**40** (8.64%)	**12** (2.59%)	**1** (0.22%)	**53** (11.45%)	**123**(26.57%)	463
	P03B	**10** (2.16%)	**47** (10.15%)	**13** (2.81%)	**1** (0.22%)	**67** (14.47%)	**138**(29.81%)	
	P03C	**12** (2.59%)	**59** (12.74%)	**40** (8.64%)	**6** (1.3%)	**85** (18.36%)	**202**(43.63%)	

These descriptive statistics reveals substantial engagement with the problem definition and potential related solutions, accounting for 43% of all speech acts averaged across the three protocol sessions. Problem definition was engaged in at a rate 2.5 times that of solutions, representing a high level of awareness of the problem being addressed, with visual support for solution generation which may have impacted the quantity of verbalization. The combination of problem definition and solution speech acts also represented a large proportion of all conversation, including 58% of all acts in Protocol A, and 38-40% in Protocols B and C. This is likely to be expected, given the ubiquity of this design move as suggested by Dorst and Cross (2001), and does not in itself represent the ethical character of the design activity. However, the agreement or disagreement allows insight into the amount of cohesion or tension among designer perspectives. Through these measures, it is clear that agreement with the presented solution or problem definition strongly outweighed any disagreement. Across all three protocols, 222 speech acts agreed with the design move in play, while only 19 speech acts represented dissent or disagreement. This level of agreement,

especially when the design task being presented is explicitly presented as manipulative, is informative and also scary to consider. This was anticipated to be the situation and we hoped to observe our participants identifying a matter of ethical concern and then reframing the brief in a more value-centered way. However, as presented in our results, participants almost uniformly chose to accept the given design task and related problem framing, resulting in outcomes that explicitly manipulated end users. Our covert intentions were to describe factors that foregrounded these unethical behaviours, which required that we begin the design task in an unethical framing in order for the designers to be able to reframe the problem to support end users. Implementation speech acts were also an important part of the design discourse, representing 34% of all speech acts. These indications of implementation generally included the finalization of solutions, as the designers were thinking through how the users would interact with the designs. Thus, while not the focus of study in this paper, these speech acts do represent relatively high engagement in both problem framing/solution activity and the concretization of these decisions in specific design representations.

4.2 Patterns of Value-laden Co-evolution

In this section, to describe the co-evolution of the rationale-solution space with an ethical lens, we will present various patterns of value-laden co-evolution observed through our data as presented in Figure 1 and illustrate these patterns through a case study. We were inspired by foundational work on Linkography (Goldschmidt, 1990) and our prior work on an extension to this method known as Ethicography (Chivukula, Gray, & Brier, 2019) and the use of these relational analytic approaches to represent (visually or conceptually) the patterns as they link from one design move to another. Providing an ethical, value-centered lens on Linkography using the language of co-evolution of problem and solution space is a the primary research contribution in this paper. We have detailed the ethical overlay of these patterns through the descriptions provided in Table 3. Finally, we use Group 1's protocol session to illustrate all the patterns from three vignettes of the session to demonstrate coherence, but these patterns exist across the dataset.

Patterns of Value-laden Co-evolution of Problem–Solution space:

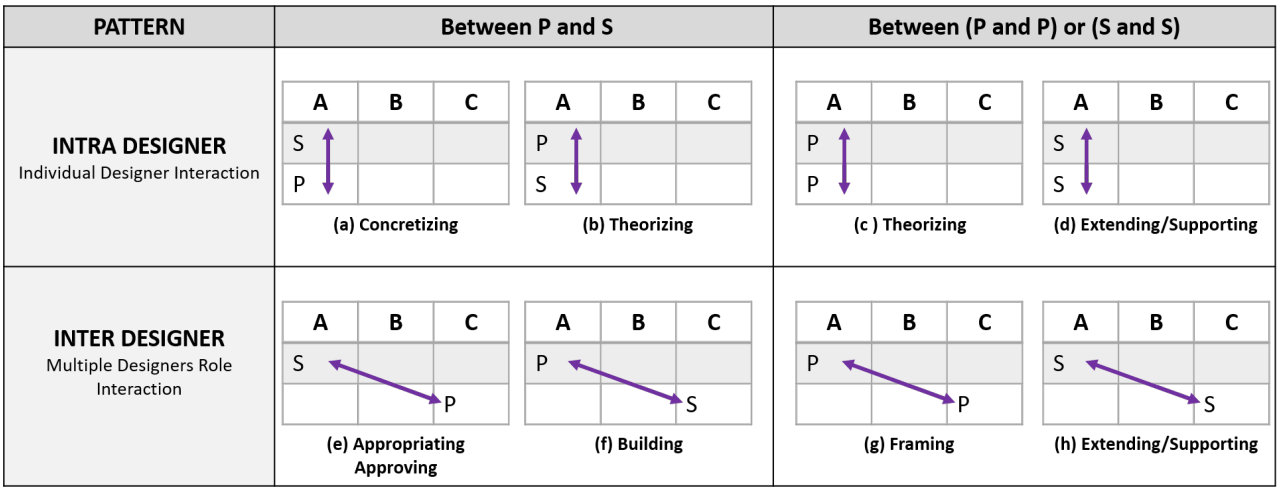

Figure 1 *Patterns of Co-evolution: describing the patterns of co-evolution of solutions and rationales within an individual designer [patterns (a)- (d)] and among multiple designers [patterns (e)- (h)]*

As depicted in Figure 1, these patterns are formed with various combinations of interaction within an individual designer's own speech acts (intra) and among multiple designers (inter) vs. a shift between solution-focused (S) and problem-definition-focused (P) or extending the same role. These combinations with examples and definitions are described in Table 3 below:

Table 3 Patterns of value-laden co-evolution with description and example speech acts.

Pattern	Description	Example Speech acts
Pattern (a) Intra S-P	Co-evolution of solution (S) and problem (P) in consecutive speech acts by an individual designer, **concretizing their manipulative intention** in one's own solution by providing a rationale.	***P02B:*** *you could bundle that and be like, "Access your microphone and contacts." So like {Put it all together}.* **[Solution]** ***P02B:*** *So they have no other choice, but to put that [agree] and access everything. 'Cause if you keep giving people options, they'll start thinking more and more about it, like something, their privacy being taken away.* **[Rationale]**
Pattern (b): Intra P-S	Co-evolution of problem (P) and solution(S) in consecutive speech acts by an individual designer**, theorizing their manipulative notion design space and amplifying evil** through the generation of solutions.	***P01A:*** *So, first of all, they [Amazon] can't really ask them directly "Oh, we're going to listen to all of your conversations." Because nobody would ever approve that, most of the people wouldn't.* **[Rationale]** ***P01A:*** *So, um, it has to be created in a way such that the user doesn't feel, you know, like um, I don't know, like very uns, the user should be sure that whatever he or she is doing is like, you know, perfectly alright and they've seen this before in like other applications maybe, like, a similar language so that there is somebody who will click yes without thinking like-* **[Solution]**
Pattern (c): Intra P-P	Evolution of problem (P) in consecutive speech acts by an individual designer, theorizing their design space **to support their manipulative intentions** and further build possibilities to achieve the design task.	***P02C:*** *Yeah. I would just go into settings and let 'em use the microphone.* **[Rationale]** ***P02C:*** *'Cause that would be very annoying.* **[Rationale]**
Pattern (d): Intra S-S	Evolution of solution (S) in consecutive speech acts by an individual designer, **extending and conceptualizing their manipulative or dark solution**.	***P01A:*** *If they try to use like a feature, let's block some features right? If they say no?* **[Solution]** ***P01A:*** *Just don't give them access to the stuff that they will need.* **[Solution]**

Pattern (e): Inter S-P	Co-evolution of solution (S) and problem (P) in consecutive speech acts, where a fellow designer is **appropriating and approving another designer's manipulative or dark solution** through a manipulative intention communicated through their rationale.	***P01C:*** *Yeah 'cause then, then you're forced to like do it.* **[Solution]** ***P01A:*** *Yeah. And most of those people will click okay.* **[Rationale]**
Pattern (f): Inter P-S	Co-evolution of problem (P) and solution(S) in consecutive speech acts, where a fellow designer is building or **operationalizing another designer's manipulative intentions** communicated through their rationale.	***P01C:*** *Yeah, are you sure want to say no to this? It's, it's kind of important, and so it just makes it really hard, really awful, to like get out of it.* **[Rationale]** ***P01A:*** *Yeah. Then you can say something like "To fully like, um, like use, like to make the fully use out of your device, uh, you would want to enable this."* **[Solution]**
Pattern (g): Inter P-P	Evolution of problem definition (P) in consecutive speech acts, where a fellow designer is **supporting the framing proposed by another designer's manipulative intentions** communicated through their rationale.	***P01C:*** *So, uh, this is interesting. To, it's, I mean, what are your guys' thoughts? Like, I mean, so it, the idea is that the word, "manipulating users to get their information," which is kind of rough. Like, but I mean, um, it's interesting. Okay, so, like what do you guys think, thought on like doing this?* **[Rationale]** ***P01A:*** *So, first of all, they can't really ask them directly "Oh, we're going to listen to all of your conversations." Because nobody would ever approve that, like, most of the people wouldn't.* **[Rationale]**
Pattern (h): Inter S-S	Evolution of solution (s) in consecutive speech acts, where a fellow designer is **extending or supporting another designer's manipulative or dark solution**.	*And then, after, do we block some of the features, do you, we ask them again at some definite feature or not?* **[Solution]** *Yeah, so that's the idea of like, yeah, the idea about like if they say no it's still gonna be like, it's gonna be like a prominent part of the app like how like advertisements, if they pop up at the bottom like constantly, if you're like not a premium member of it, 'cause they're always there, they're always popping up always saying-* **[Solution]**

In the following sections, we present three vignettes from Group 1 protocol session to illustrate the described patterns. These three vignettes were selected as a unit of analysis for the richness of the conversation as well as demonstrating all the patterns in Figure 1. We describe the context, sequence of conversation among the designers (Figures 2, 3 & 4) and occurence of patterns of interactions in the subsections below.

Vignette 1: *Making it difficult to get out of the task flow or say "no" [9:07-10:50].*

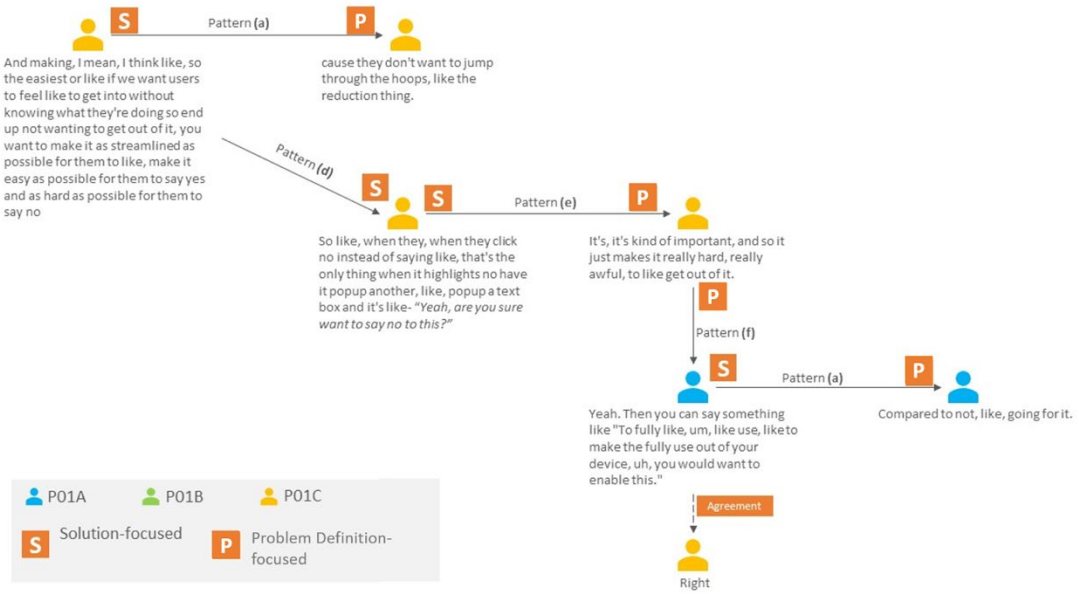

Figure 2 Sequence analysis of Vignette 1 [demonstrating patterns (a), (d) & (e)]

The sequence of conversation represented in Figure 2 occurred when the designers were planning to make the task flow "streamlined" and "hard" for the users to disagree to the microphone access. The vignette starts with P01C suggesting a solution (S) to make it "as streamlined as possible" and rationalizing that decision (P) by drawing on a persuasive principle—"reduction"—presented in the flyer given to them along with other materials. Here, we see the example of *pattern (a)* where an individual designer is trying to concretize an evil solution through a dark rationale. We observe *pattern (d)*, when the same designer P01C builds on a solution (S-S) from making it "hard" to keep nagging the user asking "*Are you sure you want to say no?*". This pattern continues from this solution to rationalize the problem definition (P) through emotions to make it "really awful" to say no to the permissions. Based on the rationale provided by P01C, P01A suggests another solution (S) to emotionally present the scenario for the user saying "to make full use of your device" the user has to agree to permissions of the microphone access, illustrating *pattern (f)* of inter-designer P-S interaction. The vignette ends with P01A rationalizing (P) the problem definition to say that the user will not have any other option than to accept as any user would like to avail the full functionality, described in pattern (a) of intra-designer S-P interaction.

Vignette *2:* *Updating the information architecture of the "Settings" menu [32:38- 33:15].*

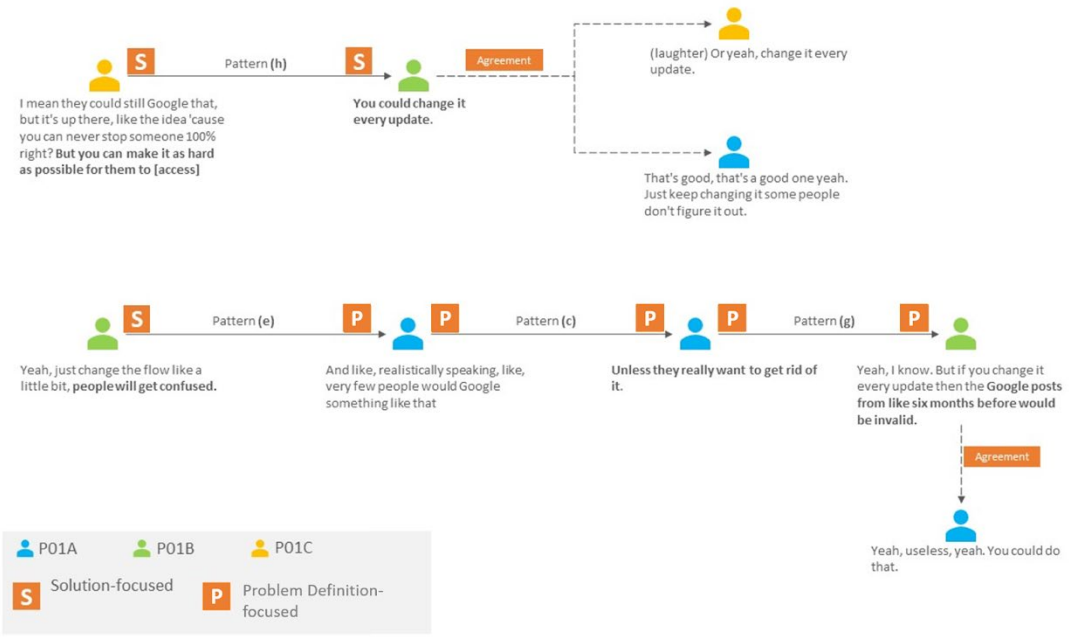

Figure 3 Sequence analysis of Vignette 2 [demonstrating patterns (c), (e), (g) & (h)]

The sequence presented in Figure 3 occurred in a conversation where the designers were trying to hide the privacy settings in the "Settings" menu, thereby making it difficult for the user to turn off the microphone access during the experience. This vignette is followed by a conversation where the designers assumed that users could always Google any solution or "help" for settings. This vignette began with P01C suggesting a solution (S) that the privacy settings should be positioned in a way that is "hard for [the users] to access". P01B continued the conversation by suggesting a solution (S) to "change [the position of privacy] every update", illustrating *pattern (h)* where one designer supports and extends another designer's evil solution. P01B continued to rationalize the problem definition (P *pattern (a)*) saying that "people will get confused" when there is a change in the task flow. This was supported through a cynical rationale by P01A that there are rare cases for users to "Google something like that", showcasing *pattern (g)* where one designer shows agreement to another through a rationale that supports the overall problem definition (P-P). P01A conditions their own rationale by offering an edge case that people would not Google "unless they want to get rid of it", just as in pattern (c) where an individual designer self-rationalizes their own design decision/ move. P01B looped back to connect the solution on every update and Google search by providing a rationale that "Google posts from six months would be invalid", illustrating another case of *pattern (g)* in this vignette. This repetition of supporting, extending and rationalizing other's solutions is evident in the interactions in this vignette through patterns (g) and (h).

5. Discussion and Future Work

Through our analysis of the value-laden co-evolution of problem definition and solution, we have demonstrated how design students reconcile or perpetuate value inclusion through practical examples and empirical data. In the following sections, we present our discussion and synthesis of the findings. First, we describe the propagation of evil that occurred through co-evolution of problem and solution among the triad of designers, drawing on a few examples from the patterns presented in this paper. Second, we highlight the need for methodological and pedagogical interventions for developing a designers' ethically aware character through the subversion of evil outcomes or the further enabling of value discovery in the co-evolution process.

5.1 Propagation of Evil through Co-evolution

The patterns of value-laden co-evolution we have defined represent how designers supported each other's decisions through extending, building, supporting and framing each other's solutions and problem definition rationale. These patterns not only represent the co-evolutionary moves, but also how specific manipulative intentions are propagated or otherwise accepted by fellow designers. We term this as a "propagation of evil" as the design process was begun within an "evil" frame to manipulate the end user; in addressing this given problem space, the designers chose to accept the frame and manipulate the user to give up their microphone access even if it meant trading off the human values of privacy and informed consent (Friedman and Kahn 2003). The designers thereby accepted and propagated the stakeholder's intention by creating and rationalizing design outcomes that were hostile to user needs, articulating and strengthening an unethical problem space in the process. This kind of propagation is resonant with existing critiques of design accountability and responsibility, such as Willis' (2006) notion of ontological designing, alongside emerging critiques of design activity from decolonizing, social justice, and feminist perspectives (e.g., Costanza-Chock, 2018; Forlano, 2017; Tlostanova, 2017).

This propagation is evident especially in patterns of inter-designer (patterns e,f,g,h) conversations and intra-designer S-P patterns (patterns a,b) to which other designers show "agreement." For example, in vignette 2 (Figure 3), the conversation starts with P01C suggesting a manipulative design outcome and P01B extending the solution shows the support for a manipulative move, to which both P01A and P01B both show agreement. In real world practice, this phenomenon of propagation of evilness or manipulation during design decision making can result in unethical designs which can have broad societal impact. In a recent paper, Dorst (2019) calls for researchers to look at "co-evolution on a societal scale," in the sense of seeing an "upward jump" from solution space to problem space. The paper provides an example of how technology (reified as a solution) impacts the "human culture, values and meaning," thereby articulating a socially-bound problem space. Based on our analysis we are able to account for social interactions among designers that may lead to the acceptance of value-misaligned design decisions, and the precursors to this acceptance that may be productively supported or disrupted through the use of design methods.

Ultimately, we view the coevolution of problem-solution as site of value manipulation and inscription which points to the importance of designer responsibility and awareness. In doing so, we link longstanding concerns from the STS community regarding the value-laden nature of design work and cognitive models of design activity from the design studies community.

5.2 Subverting or enabling value discovery for ethical action

We have illustrated how the triad of designers were involved in co-evolution through holistic results as well as identified the patterns manipulative intentions and dark solutions and their propagation through co-evolutionary moves. Through the examples presented in this paper, this decision-making included occurrences of both value-centered and manipulative intentions. These design students had previously taken coursework in ethics, and were made aware of various methods and approaches to be more value-sensitive throughout their curriculum, but instead chose to accept a manipulative problem frame in a real-world scenario when they were given a value-laden task.

It is likely that few student designers had the explicit intention to be evil, but the trajectory of each protocol did still result in solutions and related problem frames that accepted the stakeholder aims in a way that undermined the user's human values. However, interestingly and perhaps useful for future work, even in moments where evil or unethical outcomes were identified, there were moments when one or more designers recognised that they would not want those design outcomes for themselves. Thus, this study reveals opportunities to encourage the subversion or enablement of value discovery as a key part of the co-evolutionary process.

For pedagogy and practice, it might be necessary to see how to provide support to enable the value-centered and subvert the evil intentions in decision making to lead to value-centered design outcomes. This calls for a methodological support and intervention for developing an ethically aware design character, particularly in student designers, building not only a set of methods to support what Nelson and Stolterman (2012) describe as "wise action," but also the communicative ability to reframe problems to highlight areas of ethical concern.

Based on the empirical work presented in this paper, we call for more methodological tools to support the required critical reflection through the process of decision making that map onto the challenges presented by problem-solution coevolution. These tools must engage with the design complexity present in practice (Stolterman 2008), enabling designers to communicate effectively to stakeholders. This requires the ability of designers to use a variety of skills such as "methods of communicating to stakeholders, representing design activity and outcomes, promoting design approaches in the enterprise, and negotiating complexity in cross functional teams" (Gray 2014).

6. Limitations

As with all studies, our selection of study design and factors such as sample size, participants

and design task point towards important limitations of our work. Even considering a relatively small number of groups and participants, we identified numerous insights of co-evolution across multiple patterns with data saturation. While the scope of this paper and protocol focused only on the most "evil" and directly manipulative design task, the patterns of design reasoning and unethical outcomes are resonant with other protocol studies conducted we had conducted in our larger project setting with design tasks varying in the spectrum of evilness and capitalistic goals (Chivukula, Gray, & Brier, 2019; Chivukula, Brier & Gray, 2018). The differences in participant population is also important to consider in this and future studies. Using a lab protocol approach, we sought to replicating professional practice settings in terms of problem frame, but without fully capturing important ecological and business constraints that may impact designing for end users. We did include participants who have had professional experiences, increasing the ecological validity of the task and outcomes, but there are clear differences between students with professional experience and seasoned professionals working in an established business environment. However, given the difficulty in capturing designers' behaviours in relation to an unethical design task "in the wild," we find the trade-off to still provide a valuable and informative addition to the design literature.

7. Conclusion

In this paper, we have built upon existing conceptions of problem-solution coevolution, describing the ways in which values impact the negotiation of problem definition and resulting solutions. Through analysis of our protocol study findings, we identified a set of patterns of intra- and inter-designer interaction that propagated evil intentions into design outcomes, described through the language of coevolution of problem-solution. We build upon these findings to describe the need for further attention to the ethical dimensions of design activity, and the potential role of design and communication methods in encouraging the subversion and redirection of problem space and solution manipulation to foreground ethical aspects of design work.

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