Improvising Interaction: Toward Applied Improvisation Driven Social Robotics Theory and Education

Tom Williams
Colorado School of Mines
Golden, CO, USA
twilliams@mines.edu

***Abstract*—Theater-based design methods are seeing increased use in social robotics, as embodied roleplay is an ideal method for designing embodied interactions. Yet theater-based design methods are often cast as simply one possible tool; there has been little consideration of the importance of specific improvisational skills for theater-based design; and there has been little consideration of how to train students in theater-based design methods.**

We argue that improvisation is not just one possible tool of social robot design, but is instead *central* to social robotics. Leveraging recent theoretical work on *Applied Improvisation*, we show how improvisational skills represent (1) a set of key capabilities needed for any socially interactive robot, (2) a set of learning objectives for training engineers in social robot design, and (3) a set of methodologies for training those engineers to engage in theater-based design methods.

Accordingly, we argue for a reconceptualization of Social Robotics as an *Applied Improvisation* project; we present, as a speculative pedagogical artifact, a sample syllabus for an envisioned Applied Improvisation driven Social Robotics course that might give students the technical *and improvisational* skills necessary to be effective robot designers; and we present a case study in which Applied Improvisation methods were simultaneously used (a) by instructors, to rapidly scaffold engineering students' improvisational skills and (b) by those students, to engage in more effective human-robot interaction design.

***Index Terms*—Applied Improvisation, Theater-Based Design, Social Robotics Education**

I. Introduction and Motivation

Movement-based and theater-based design methods are seeing increased use in the design of social robots [1]. For example, there has been substantial recent work in social robotics that has leveraged *Bodystorming* [2] (cf. [3], [4], [5], [6]) and *Embodied Sketching* [7] to generate design ideas through prop-augmented improvisational roleplay. Within the space of movement-based design methods, a number of *theater-based* methods that rely more heavily on explicit *roleplay* have been proposed. This includes methods where designers improvise themselves, such as Service Walkthroughs [8], as well as methods in which designers *observe* improvising actors [9].

Yet theater-based design methods are often cast as just one tool in the HRI designer's toolbox – a sentiment that is reflected in the design of courses teaching Human-Robot Interaction (HRI) design to student. Few HRI courses specifically teach students about theater-based design methods, and when they do, theater-based design often has very restricted coverage [10]. Moreover, in both research and education, the use of roleplay is often discussed without more careful delineation of what exactly that roleplay involves, at a fine-grained level. Finally, when improvisational roleplay is used in HRI education, it is often taught primarily through the lens of games that are concerned with achieving comedic effects, but that may have uncertain grounding in precise pedagogical goals [9]. For example, the exercises used to engage students in improvisational roleplay when teaching robot design are often limited to traditional short-form improv gamesthat produce a fun and engaging environment but that may, on their own, sacrifice utility as design tools in order to obtain those benefits [9]. Finally, theater-based design methods are sometimes *discouraged* due to the acting training they ostensibly require, and there has been little consideration of how engineers and designers might be given such training.

In this work, we argue that improvisation is not just one possible tool for robot design, but is instead *central* to the project of social robotics. By leveraging recent theoretical work on *Applied Improvisation*, we show how the skills needed to engage in improvisation represent (1) a set of key capabilities needed for any socially interactive robot, (2) a set of learning objectives for training engineers in the design of social robots, and (3) a set of methodologies for training those engineers to engage in theater-based design methods.

In doing so, we argue for a reconceptualization of Social Robotics as an Applied Improvisation project; we present, as a speculative pedagogical artifact, a sample syllabus for an envisioned Applied Improvisation driven Social Robotics course that might give students the necessary technical *and improvisational* skills necessary to be effective robot designers. And, as a case study of the effectiveness approach, we describe a theater-based design lab structured according to the Applied Improvisation theory leveraged in this work, in which (a) instructors used exercises grounded in Applied Improvisational Theory to rapidly scaffold engineering students' improvisational skills, and (b) students used those exercises to more effectively engage in human-robot interaction design.

This work was funded in part by NSF grants IIS-2044865 and SBE-2418199. We would like to thank Not My Robot members Lauren Lyga, Chris DeVito, Sara Cantor, Maria Lazarte, Kaitlin Kennedy, and Joey Cirasa, and the students of Colorado School of Mines' Fall 2024 HRI class.

II. Theater-Based Design

In this section, we will discuss the status quo of theater-based robot design methods. *Movement-based* design methods writ large have been shown to be particularly effective tools for designing interactions with embodied technologies [11]. Popular movement-based design methods include *Bodystorming*, a situated generative design method focused on generating multiple design ideas through prop-facilitated roleplay of expected use case scenarios [2]. Another popular method is *Embodied Sketching*, which uses playful movement-based ideation and props to elicit a creative mindset [7]. Within the space of movement-based design methods, a number of *theater-based* methods that rely more heavily on explicit *roleplay* have been proposed. These include *Informances* [12], [13], a situated generative design method that combines elements of performance, scenario-based-design, and Wizard-of-Oz within an improvisational framework, and *Service Walkthroughs* [8], which helps designers to prototype and evaluate service-providing technologies (within a Service Blueprinting framework) (cf. [14]) through enactment of service moments.

In robotics, theater-based design has proved particularly useful, as roleplaying interactions with an embodied technology can be highly illuminating in designing effective and natural spatial, verbal, and non-verbal interactions. These methods are also notable in their alignment with Feminist Human-Robot Interaction's call to elevate emotion and embodiment in robot design [15]. Recently, there has been substantial robot design work using bodystorming in particular [4], [3], [5], and there have been some recent roleplay-based design efforts [16]. Yet as Baraka notes, most previous improv-driven robot design work is grounded in dance rather than theater (e.g., [17]). Notable exceptions include Li et al.'s use of improv techniques for communicating status [18], Greer et al.'s encouragement of focus groups to improvise while robots perform pre-programmed behaviors [19], [20], [21], Jochum et al.'s exploration of audience-robot interactions [22], Rond et al.'s use of robots as creative partners for trained improvisers [23], and Dertien's use of actor-led improvisation to facilitate HRI design education [9].

However, across these methods, the specific *ways* that roleplay is used are not often well articulated – nor are the specific connections between roleplay and the *facets* of Human-Robot Interaction that roleplay-based methods are used to design for. Finally, there has been too little attention paid to the specific ways that specific roleplay based activities can be used to scaffold designers and engineers abilities to effectively participate in roleplay based design activities. We argue that the field of *Applied Improvisation* provides the crucial link needed to provided this precision and new knowledge.

III. Applied Improvisation Theory

We argue that the theater-based design methods described in the previous section can be better understood when viewed through the lens of *Applied Improvisation*. Applied Improvisation [24] is an emerging field that seeks to apply improvisational theater principles to non-theatrical contexts. Applied Improvisation has been used across domains like education, therapy, and leadership development, where success relies on one's ability to genuinely listen and spontaneously respond to others. Across these domains, improvisational theater based exercises have been shown to be particularly effective relative to other activities at cultivating participants' abilities to build empathy and listen constructively to others [25], think creatively and spontaneously [26], tolerate uncertainty [27], and improve self esteem and self efficacy [28].

While roleplay-based robot design has not previously been cast as an application of Applied Improvisation, it falls firmly within Applied Improvisation's scope, suggesting that theater-driven design methods could leverage insights from the Applied Improvisation community. Unfortunately, the Applied Improvisation community is relatively nascent, with professional networks like the Applied Improvisation Network (AIN) merely two decades old, and little *theoretical* knowledge disseminated through the network.

One exception is the work of Pelletier, who has analyzed the key skills needed for Applied Improvisation [29], and synthesized this analysis into an *Interactive Skills Referential* with three key skill areas: *hyperperception*, *action rapide* (rapid action), and *qualité de la communication* (quality communication). Here, Hyperperception comprises skills in listening, observation, peripheral vision, and multi-tasking. Rapid action comprises skills in rhythm (or pacing) and the ability (and willingness) to respond to what is offered rather than stick to one's preconceived plans, framed in terms of Gibsonian behavioral affordances [30]. Finally, quality communication is broken into eye contact, nonverbal communication (posture, gesture, facial expressions), prosody, and mobility. Pelletier fits these skills into a framework that explains how these improvisational capabilities interact: First, the improviser engages in hyperperception in order to quickly recognize and reflect on unexpected actions. Then, the improviser uses those reflections to generate a rapid behavioral response, which they realize through quality communication.

This *Interactive Skills Referential* and its account of the cognitive process of improvisation represent a theoretically grounded framework for a key subset of human behavior: specifically, that behavior which is spontaneous, interactive, and performative (but not necessarily theatrical): the precise type of behavior that is typically of greatest interest to social robotics. After all, social interactions between humans and robots may be best interpreted as improvised theatrical performances [31] between humans and robotic *depictions* of agentic characters [32]. As such, we argue that Applied Improvisation, as grounded in Pelletier's *Interactive Skills Referential*, should be used not as yet-one-more-tool for social robot design, but can instead as a *unifying theory* for characterizing the space of skills needed to enable natural and human-like human-robot interactions. Moreover, we argue that Pelletier's *Interactive Skills Referential* can be used to motivate a specific curriculum for teaching social robotics students about the building blocks of social interaction – while also teaching those students the skills they need to engage in more effective robot design.

IV. Towards an Applied Improvisation-Based Theory of Social Robotics

Let us consider why Pelletier's taxonomy of improvisational skills might make a compelling framework for reasoning about the types of capabilities needed to enable truly *social* robotics. To help us reason through this, we can first consider what the skills within Pelletier's *Interactive Skills Referential* are intended to accomplish. Without hyperperception, a human improviser is likely to miss the truth of what's happening around them, and fail to see opportunities for taking an interaction in new directions that are genuinely responsive to their interactants. Without rapid action, the human improviser is unable to respond to what they have perceived in a timely and coherent way. And without quality communication, the human improviser is unable to make their response lifelike, dynamic, and likely to be correctly interpreted by an interactant. In short, the aim of these skills is to enable human improvisers to perform interactions in a way that is authentic, dynamic, and spontaneous rather than shallow, rigid, and scripted – the same challenge that social roboticists take on when they seek to enable their robots to engage in genuinely social interactions.

Clearly, these capabilities are not on their own sufficient for social interaction. But they may not need to be. In Applied Improvisation, it is assumed that the human improviser has some basic knowledge that does not need to be "taught" for them to engage in natural interactions. Human improvisers do not need this same level of careful training to speak sentences that are grammatical, leverage common-sense knowledge, and respect sociocultural norms. That is, the basic syntax, semantics, and pragmatics of human language do not need to be *taught* to enable human improvisation. So too might roboticists view this base of linguistic and cultural knowledge as the prerequisites onto which socially interactive – that is, *improvisational* – capabilities are layered. In other words, we might view these improvisational skills as those that move us past the shallowly-social interactive capabilities provided by most task-based language-oriented cognitive architectures [33] or Large Language Models [34], [35].

V. Toward Applied improvisation-Based Coursework in Social Robotics

If we accept this argument, and view the skills of the applied improviser as the same facets that must be uniquely accounted for in social robot design, this helps to reveal a curriculum for structuring social robotics classes. To visualize this revealed curriculum, we present a hypothetical syllabus in Table I, which serves as a *speculative pedagogical artifact* to envision a radically different mode of robotics education.

Moreover, this re-interpretation of social robotics as an Applied Improvisation project helps to reveal how in the course of such a curriculum we might progressively teach students the improvisational skills needed to successfully engage in theater-driven design methods. As described at the beginning of this paper, theater-driven design methods have become increasingly popular within social robotics, but are difficult to adopt due to the lack of acting training amongst most designers (let alone most undergraduate engineering students). We believe that by proceeding through social robotics topics in an order informed by Applied Improvisation theory, natural opportunities will arise for scaffolding robotics students' acting skills, in a way that simultaneously (1) provides students with a deeper, more *embodied* understanding of the improvisational principle under consideration, (2) provides students with experience leveraging that improvisational principle in service of Applied Improvisational roleplay, (3) trains students to watch for the use (and effects thereof) of that principle when observing applied improvisation-based design exercises, and (4) better prepares students to model that behavior and implement it into social robot interaction designs. Moreover, based on recent results in organizational psychology, we expect that these activities would increase students' self esteem and perceived self-efficacy both as improvisers and as robot designers [28].

In the hypothetical syllabus shown in Tab I, we specifically envision social robotics education as a fifteen-week course, with two 75-minute sections per week that reflect an Applied Improvisation vision of social robotics, with students learning improvisational theater techniques in the first session of each week in order to build *embodied knowledge* of a key dimension of human improvisational interaction, and with students then applying that embodied knowledge in the context of robot design in the second session of each week. We invite the reader to consider what an HRI course at their university might look like if it followed the form visualized in this *speculative pedagogical artifact*. In the next section, we provide a case study that demonstrates the feasibility of this type of approach.

VI. Case Study

As a practical example of how improvisation-based coursework might play out in robotics classrooms, we will describe in this section a case study conducted at Colorado School of Mines, in which we carried out two two-hour improvisation-driven lab sessions, that helped students unlock their embodied knowledge in order to bring their designs to life. Reporting and analysis of educational activities in this course are approved by Mines' Humans Subjects Research Office.

A. Educational Context

The case study described in this section was carried out in the context of a Human-Robot Interaction class comprised of undergraduate and graduate engineering students. The students had been divided into 3-4 student teams, and had already gone through several weeks of preparatory work, during which they had identified key stakeholders working in domains with possible social robotics applications, performed interviews with those stakeholders to identify their needs, conducted. thematic analyses of their interview results, identified key design principles for their domains, grounded in both those interview results and the research literature, and gained preliminary experience programming the Nao social robot [36].

In the week preceding the case study, the students had learned about traditional HRI design methods, performed a "persona design" lab in which they created robot characters

Wk	Topic	Tuesday	Thursday
1	Introduction	Social Robot Design Fundamentals	Social Robotics Software
2	Listening	Yes-And, One-Word-Story, I Am a Tree	Speech Recognition
3	Observing	Relationships, Shape Exercises	Behavior Recognition
4	Peripheral Vision	Sit-Stand-Kneel, Improvised Dance	Person detection and tracking
5	Multitasking	Object work I	Parallelism in Robot Architectures
6	Behavioral Affordances	Patterns and Game	Dialogue, Relevance, Coherence
7	Pacing	Speak As One, Mr. Know It All, Silence	Turn Taking
8	Eye Contact	Focus, Meissner exercises	Gaze
9	Facial Expression	Emotion	Affect and Empathy
10	Prosody	Character	Persona Design
11	Posture	Status	Body Language
12	Gesture	Character-Driven Object Work	Communicative Gestures
13	Mobility	Depth, Level, and Distance	Proxemics
14	Free Work		
15	Presentations		

TABLE I: Sample Syllabus

whose personalities were aligned with their teams' design principles. In the days before the class in question, students had each been asked to create storyboards depicting their characters in interactions motivated by their interviews (e.g., Fig. 1). On the day of the class in question, students were instructed to meet outside. Upon arriving, they were met by a design team assembled for the purposes of the day's exercises.

B. Participants

The design team leading class included the instructor and five members of Not My Robot, a robot-themed improvisational theater troupe based in Denver, Colorado. Before the class, the members of Not My Robot worked with the instructor to iterate on a lesson plan that would leverage improvisational theater methods to scaffold students towards embodied sketching based interaction design. The class was comprised of 47 students, split into two lab sections of 30 and 17 students respectively. About two-third of students identified as men, and about one-third identified as women (gender identity was not formally collected from students)[1]. 32 of the students were undergraduates, and 15 were graduate students. All students came from engineering disciplines, and none had prior experience with improvisational theater. 44 students consented to having their class activities analyzed and reported on for research purposes – the other students' responses to class surveys and activities will not be reported in this work. Of those 44, 34 provided feedback on the theater-based design activities. This feedback will be presented and summarized as the associated activities are described below.

C. Class Structure

The class was split into two sections, with each half participating in a different two-hour outdoor lab session. Within each lab session, students were further split into two groups,

[1]These demographics highlight how our approach serves as a Feminist intervention [15] into a male-dominated robotics education environments that typically elevate mathematical abstraction over embodiment – yet also encourage reflection into how the even starker gender differences seen in other robotics classes might challenge efforts to employ this approach.

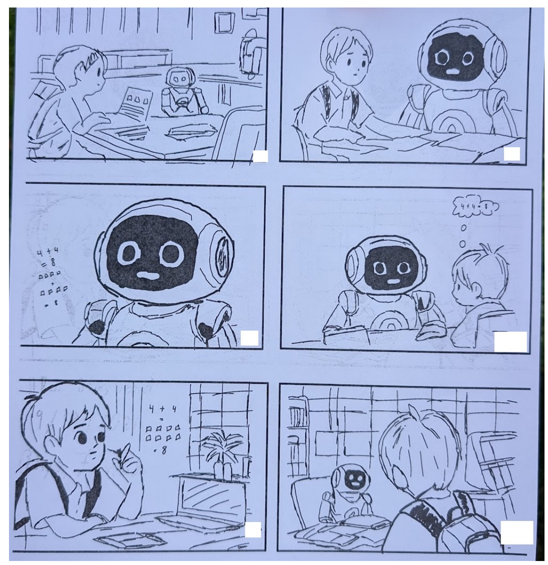


Fig. 1: A student storyboard depicting an envisioned interaction.

to facilitate equitable participation in theater-based design activities. Once they arrived, students were led through a series of theater-based design exercises. After the first of the two lab sessions, the design team reflected on the success of each planned activity, and revised those activities for use in the second lab section. Below, we report the finalized set of activities used in the second lab section.

1) Listening and Observing: To begin the lab, students were led through warm-up exercises designed to encourage *hyperperception* and *rapid action*, i.e., to *listen* and *observe*, and then rapidly produce an appropriate response.

Specifically, we began with *zip-zap-zop* and *pass the clap*: games that require extremely low buy-in (only requiring participants to point or clap towards each other, and say predefined words) yet that encourage participants to pay close attention to and directly respond to the other participants.

Next, students were led through a game of *mind meld*. In this game, two players step out and each say a word of their

Fig. 2: Drawing based on photograph taken during an early exercise. Trained improvisers on the left describe to the students on the right how the next exercise will be performed.

choice at the same time. Then two more players step out and each say a new word at the same time, trying to choose words that fall at the semantic midpoint between the words in the previous round. This pattern is repeated until a pair of players step out and says the exact same word at the same time.

Like the first round of games, *mind meld* also encourages *hyperperception* and *rapid action* skills by encouraging players to listen to each other and quickly build on each other's previous game moves. Unlike the first round of games, however, mind meld encourages increased player agency over what is said, encourages players to contribute creatively, encourages a mixture of convergent and divergent creative thinking, and encourages players to participate on their own initiative.

These types of games are not the types of activities students typically expect in robotics classes. Indeed, during these initial exercises, one student spontaneously exclaimed that they were having more fun than they had ever had in any previous class over their past four years of undergraduate education. However, these games were important for several key reasons. First, these games encouraged a fun and creative atmosphere in which everyone was invited and expected to contribute in low-stakes ways. Second, these games encouraged students to adopt an attitude in which they carefully listened and watched for the actions of others, and built on those actions in ways that responded to their partners and could be easily responded to by their partners. In short, these exercises encouraged students to build their *hyperperception* and *rapid action* skills – and to adhere to Grice's cooperative principle [37].

2) Pacing: Next, students were led through a second series of games that encouraged them to attend to the pacing of an interaction, a key dimension of *quality communication*. First, students played *one-word story*, in which they collectively told a story one word at a time. Next, students played *one-line story*, in which they collectively told a story one sentence at a time, preceding each sentence with "yes, and". Finally, students played *Mr. Know-it-All*, in which a trio of students were asked a series of questions by the other students, and would speak their answers "as one", speaking their words at the same time in a way that requires them to tightly attend to each other while speaking.

These exercises' attention to pacing not only introduced *quality communication*, but also further encouraged students to build and leverage their skills in *hyperperception* and *rapid action*. Specifically, students built on the games from the previous round by contributing full sentences rather than single words, and by paying to attention to other students' contributions not simply at the level of a dialogue turn, but moreover at the level of the phoneme.

3) Multitasking and Mobility: At this point in the lab, students were comfortably contributing full lines of creative and responsive spoken dialogue. The next round of exercises built on this by encouraging them to collectively coordinate their *body movements* during that dialogue, in ways that simultaneously extended existing *hyperperception* skills and built new *quality communication* skills.

Specifically, students were led through a series of *assembly* games, in which each group collectively roleplayed assembling and manipulating a variety of imaginary objects. For example, students began by working together to assemble and transport an imagined table, working together to mime assembling that table and moving that table across the lawn[2].

This exercise served three purposes. First, it encouraged students to think about *object work*, i.e., the ways that one moves their body to naturally convey manipulation of imagined props. Second, the exercise encouraged students to think about turn taking, i.e., the ways that interaction partners naturally exchange the conversational floor during conversation, and especially the turn taking dynamics required for collaborative tasks such as assembly and transport of furniture. Third, the exercise encouraged students to think about proxemics, i.e., the ways that interaction partners position their bodies with respect to each other during different phases of the task.

4) Eye Contact and Gesture: Now that students had practiced incorporating verbal and spatial dimensions of *quality interaction*, we coached them to integrate nonverbal cues. To facilitate this, students were invited to participate in a series of dyadic scenes. In each scene, one student approached the other, pretending to be lost, and asked for directions to a location of their choice on campus. The second student was then tasked with responding as authentically as possible to that request. During each of these dyadic interactions, the other students were encouraged to pay attention to the speech, gaze, gesture, and proxemics used by the two conversational partners.

By the end of this exercise, all students were participating in dyadic scenes with full attention to their verbal, nonverbal, and proxemic behaviors, with the intention to be as authentic as possible, while being watched by their classmates. Similarly, those watching the dyadic interactions were participating by watching their classmates with an eye towards authenticity with respect to each of these key dimensions of interaction.

5) Posture and Service Design: In the final exercise, students were asked to simulate a multi-party interaction at

[2]One group spontaneously built on these instructions by miming an imaginary game of beer pong, simultaneously demonstrating (1) their ease of collaboratively engaging with the fictional environment they had co-created, and (2) that the engineering students in the class were apparently having more fun on the weekends than their instructor expected.

a Qdoba restaurant. Three students pretended to be Qdoba workers performing different tasks necessary for assembling and ringing up a burrito order, and the other students queued up and simulated waiting in line and then proceeding through a line to order and pay for a burrito[3].

This exercise encouraged students to reflect on how interactions are shaped by the role and status of interactants, and to synthesize the lessons learned thus far in the lab. What is particularly important to us about this exercise is the way that students leveraged theater-based design methods in a way that was highly authentic to the way those methods are used in the context of service design. As such, even though at the beginning of the lab, students had no prior improvisational experience, little experience with being asked to engage and playful ways in engineering classrooms, and in many cases, had a demonstrated reticence to speak or interact in any way in a classroom environment, by the end of the hour, the scaffolding of these exercises had brought all students to a point of collective playful participation in theater-based design methods, in ways that mirror the use of those methods by professional designers in the context of service design.

This is not to say, of course, that all students were equally comfortable; nor is this say that students had fully internalized all of the lessons from across these series of exercises; nor that all students were participating in those exercises at the level of trained improvisers or trained service designers. Indeed, in practice, we would expect to build up to this point over the course of a semester, e.g. by following the syllabus provided in the previous section as a speculative pedagogical artifact. Nevertheless, we found it inspiring to see the point to which students were able to get by the end of this hour, due in part to the careful scaffolding of these pedagogical exercises.

6) Embodied Sketching: In the second hour of the lab, students were invited to apply what they had learned in the first hour to their robot design projects. Students broke into their project groups, and gathered the storyboards that they had brought to class that illustrated their envisioned interaction designs. Each group then went through the following process for each of the group's storyboards.

First, the student whose storyboard was currently being reviewed showed it to their group, and walked the group through what they had intended to communicate through it.

Next, that student stepped into the role of *director*, casting their groupmates as the interactants within their storyboard. For example, a student whose storyboard described an educational interaction cast one of their group members as the educational robot, and cast another of their group members as the child shown interacting with their robot in the storyboard.

Then, the director invited their group members to act out their storyboard, while they looked on. After each such

[3]Even though students were instructed to order burritos, they in practice ordered a variety of food items, with one student in every group choosing independently to order a hamburger, for reasons that remain a mystery. Nevertheless, through this deviation, students demonstrated that they were playfully engaging in their scenework, while authentically and fully committing to the base reality of the scenes determined by their classmates' prior choices.

Fig. 3: Drawing based on photograph taken during embodied sketching exercises. Across various points in the scene, we see students in various stages of design, from discussing storyboards to enacting those storyboards, sometimes seated, sometimes standing, sometimes (when appropriate to the storyboard) even lying down. We can also see (on the far left and far right) trained improvisers watching groups performing embodied sketching, ready to provide feedback as needed.

enactment, the director considered whether that enactment had been (1) highly naturalistic with respect to the verbal, nonverbal, and proxemic dimensions highlighted during the previous hour, (2) aligned with the design principles the group had decided on, and (3) a good representation of the storyboard that they had drawn. If any of these considerations failed to hold, the director made one of three choices: they either (1) gave direction to the actors in how to adapt their verbal, nonverbal, or proxemic behaviors, (2) changed or annotated their storyboard to make the interaction depicted in the storyboard more natural or more adhering to the group's design principles, or (3) did both.

Finally, students iterated through this process until the behaviors of the actors matched the storyboard, the actors' behaviors were perceived as maximally naturalistic, and the actors' behaviors were viewed as maximally aligning with the group's design principles. After finalizing each storyboard, students moved on to the next storyboard. When all three storyboards had been finalized through this iterative process, the group chose a single storyboard as the interaction that they would seek to enable over the remainder of the semester.

By the end of this process, students were thus successfully leveraging their embodied knowledge, as unlocked through the first hour of improvisational exercises, in order to effectively design and critique naturalistic and value aligning interactions for interactive robots. This is not to say of course that all design processes were equally successful, nor that all students fully and successfully engaged in what was asked of them. Many groups, for example, ultimately forgot to attend to the design principles their groups had previously articulated, and instead focused narrowly during this exercise on the naturalness of interactions. Again, we expect this problem would be resolved in the context of a semester-long HRI class fully grounded in Applied Improvisation.

7) Subsequent Weeks: Over the weeks following this lab session, students were led in more detail through each of the topics that had been implicitly covered in the theater-based design lab. This included class sessions on turn taking and collaboration, spatial interaction, verbal interaction, and nonverbal interaction. Across these subsequent classes, the design activities from the theater-based design lab served as touchstones that could be called back to during classroom discussions. For example, during discussion of work from the HRI literature on gaze modeling [38], students were invited to connect that work back to the gaze behaviors that had been used in the "Lost on Campus" and "Qdoba Line" exercises. Similarly, during discussion of work from the HRI literature on turn taking and collaboration (especially prior work on handover interactions [39]), students were invited to connect that work back to the "Table Assembly" exercise. In this way, instruction on the theory and computational modeling of human-robot interactions was directly facilitated by the embodied knowledge that students had collectively established during their theater-based design exercises.

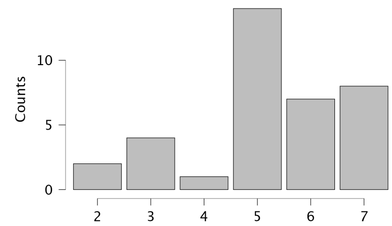
D. Student Perceptions

Several weeks after the exercises, we surveyed students about their perceptions of the theater-based design exercises. Specifically, we asked students about their level of enjoyment, anticipated and actual comfort, obviousness of the applicability of the exercises, and perceived usefulness of the exercises both in solidifying understanding of course content and in developing students' interaction designs[4].

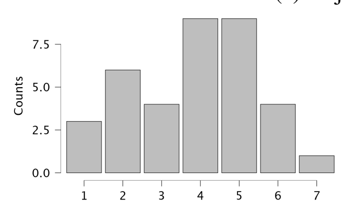
1) Enjoyment: Nearly all students reported enjoying the exercises (M=5.22/7, SD=1.44, Fig. 4a). Students reported enjoying the activities specifically because they were fun, but also due to the connections they were able to draw beyond the activities. P41 wrote "Being able to interact with people that don't necessarily have technical knowledge of robots or HRI, but have applicable skills to the design process was a very fun experience", while P3 wrote "The activities allowed us to connect our story boards to real-world scenarios and offered a fun and unique way to learn!". P5 observed "I enjoyed the exercises a lot! Seems like a great way to get often socially awkward engineers comfortable with [theater-based design]." However, P7 noted "I would have enjoyed the activity more if I had been paired with more graduate students... - the undergrads were too unserious about it", suggesting a need to account for different types of students when structuring these activities. For others who did not enjoy the exercises, reasons given often included (1) social anxiety, (2) lack of perceived relevance, (3) desire to get more time working with the robots themselves.

2) Comfortability: While students reported initial uncertainty as to whether they would feel comfortable performing the exercises (M=3.86/7,SD=1.59, Fig. 4b), they reported feeling surprisingly comfortable after being led through them (M=5.25/7,SD=1.52, Fig. 4c). Some students reported that the comfort they achieved was explicitly due to the structure of the exercises. P42 wrote "In the past... improv activities... always required uncomfortable on the spot thinking that I don't do well with. However, these activities were straightforward and more structured in a way that helped me feel comfortable". Similarly, P7 wrote "I am not a 'theater' person so I didn't really think that I would feel like I knew what I was doing, but I was open-minded to trying something new. When we actually started the exercises, I had a great time." Some students, like P33 explicitly enjoyed stepping into unfamiliar roles: "For our group, theater-based design involved some of us playing the role of the robot and others playing the role of the child. Honestly, playing a child who doesn't follow instructions was really fun. Based on my past experience, roleplaying isn't usually enjoyable and can feel a bit awkward. But this time, it was different!" However, other students, like P37, expressed discomfort surrounding the more applied portions: "I felt very comfortable during the improv games - they were simple and easy to understand. But I was less comfortable acting out the storyboards - they contain more complicated interactions."

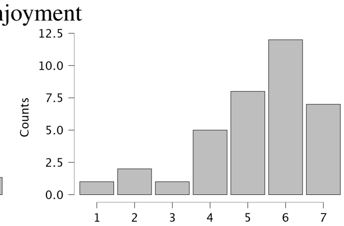
3) Connections: While students were originally uncertain about the connections between the theater-based design ac-



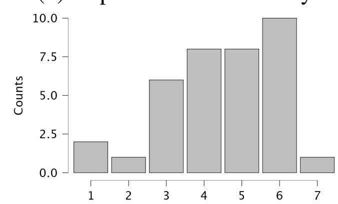
(a) Enjoyment



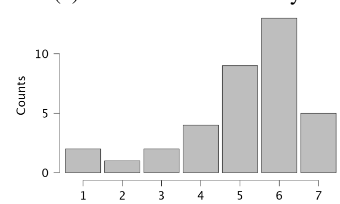
(b) Expected Comfortability



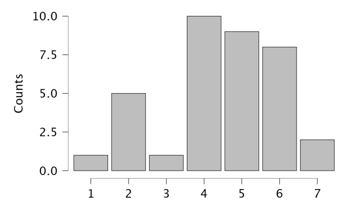
(c) Actual Comfortability



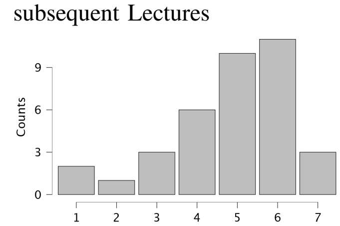
(d) Clearness of Connection at Time of Lab



(e) Clearness of Connection after subsequent Lectures



(f) Perceived Benefit to Understanding Course Concepts



(g) Perceived Benefit to Effective Interaction Design

Fig. 4: Student Perceptions of Theater-Based Design Lab

[4]The survey (https://osf.io/6fmb3/) used 7-point Likert items and free response questions. All responses were anonymized after removing students who had not provided consent for their data to be used. The use of a single, delayed survey reduced student workload, but is a methodological limitation.

tivities and interaction design (M=4.47/7, SD=1.48, Fig. 4d), they reported that the relevance of the activities became clearer after the weeks of technical and theoretical HRI lectures that followed the exercises (M=5.11/7,SD=1.56, Fig. 4e). For example, P41 wrote "Certain exercises seemed odd at first, but after discussion made clear connections to class. For example, the "giving someone directions" exercise clarified how gaze and motion play into conversation." P37 wrote "Being able to see how gestures and motions that we humans take for granted... have a huge impact on empathy and conveying emotion became more apparent after we had lectures on them. It didn't quite make sense in the beginning... but after the assigned readings and the lectures... there is a visible connection." Similarly, P2 wrote "During the lab, I saw some connections between the improv exercises and robot interaction. However, after studying gaze, turn-taking, and gesture in the past few weeks, I now see how these non-verbal communication elements are crucial in human-robot interactions." And P24 wrote "At the time of the lab, I didn't think much about how it applies to HRI since the exercises we had were mostly focused on improvising real life scenarios. However, after learning about the theories, I do feel some connections. For instance, with the table [holding] exercise, I do notice that people were looking at each other's hands when performing actions such as lifting or dropping it. This relates to joint attention."

For other students, this connection became especially clear after working to implement their designs on social robots. P40 wrote "I didn't see the connections as clearly during the improv lab [but] after trying to actually implement some of those strategies for the Nao and seeing how challenging it is to make an interaction appear natural, analyzing people's behaviors from the improv activities connects a lot more." Similarly, P39 wrote "After conducting the other labs following the exercise, my team and I implemented several things that we acted out during our improv and storyboarding sessions. For example in the gaze lab we focused on the robot looking at the student when the student was talking or asking a question, but looking back to lecture/review material while it was tutoring, which is something we had acted out and decided upon."

4) Importance for solidifying understanding: Students were positive but split about the helpfulness of the theater-based design exercises in helping to solidify their understanding of course content (M=4.47/7, SD=1.52, Fig. 4f) but more clearly felt that the exercises contributed directly to their actual interaction designs (M=4.83/7, SD=1.52, Fig. 4g).

Students who were positive about the exercises highlighted the ways that they led to concrete changes in their interaction designs. For example, P34 wrote "The most beneficial thing for modeling our interaction was probably acting out our storyboards. This changed a lot of our thinking about how things would go as we realized we needed to be much more intentional about how the interaction played out". Similarly, P1 wrote "I really think that acting out our interaction truly helped us to find what would be feasible with the Nao. My group members and I frequently think back to the things we discussed on the activity day and I feel that the concepts in class in relation to what we discovered through the activities help to give us more foundation and justification to our design decisions." And P12 wrote "By acting out our storyboards, we found some gaps in our planned interaction, and I'm guessing the theater exercises helped people open up enough to feel comfortable acting those out thoroughly."

Students who were less positive about the utility of the exercises pointed to the difficulty of implementing designed interactions, especially given many students' reliance on LLM-based interaction. For example, P33 wrote "Given the difficult nature of approaching the balance between the new skills for the Nao and prompt engineering to create a final interaction, it is difficult to know what to look for that could be feasibly implemented in the time frame." Similarly, P10 wrote "I think we also got some ideas about what we could do with the robot, but it's been hard to think of ways to engineer that into our GPT prompt to produce those behaviors."

VII. Discussion and Conclusion

In this paper, we have argued that while improvisation is often viewed as just one tool in the HRI designer's toolbox, it is in fact central to the project of social robotics, and should play a more prominent role in the ways we educate students about social robotics. By leveraging insights from the theory of Applied Improvisation, we have been able to make three key contributions in this work. First, we have shown how social robotics might be reinterpreted as a project in which designers seek to endow robot with the interactive skills of human *improvisers*. Second, we have presented a speculative pedagogical artifact to envision how social robotics course-work might be more effectively structured through alignment with the principles of Applied Improvisation. And finally, we have presented a case study demonstrating the benefits of this approach even within a brief two-hour lab session, with students overall enjoying this approach, finding it comfortable to engage in, seeing clear relevance of the approach especially after grounding in lectures and implementation labs, and seeing benefit to their understanding of course concepts and especially to their effective design of interactive robots.

It is not our intention in this work to argue that theater-based methods are the "only" or "most important" type of robot design method. Indeed, improvisation-based methods should be complemented by other approaches [40], from ready-made prototyping to pretotyping, from animation to puppeteering, from value mapping to co-design. Moreover, theater-based methods may be more readily applied to socially agentic and anthropomorphic robots than to less agentic and mechanomorphic robots (although cf. recent work on techno-mimesis [41] and robomorphism [42]). Nevertheless, we believe that through the contributions made in this work, there is good reason to rethink improvisation as a central and foundational pillar (rather than elaborative detail) of social robotics, and to consider improvisation writ large as central to the theory, practice, and pedagogy of our field.

References

[1] I. A. Troughton, K. Baraka, K. Hindriks, and M. Bleeker, "Robotic improvisers: Rule-based improvisation and emergent behaviour in hri," in *Proc. ACM/IEEE International Conference on Human-Robot Interaction (HRI)*, 2022.

[2] D. Schleicher, P. Jones, and O. Kachur, "Bodystorming as embodied designing," *interactions*, vol. 17, no. 6, pp. 47–51, 2010.

[3] P. Abtahi, N. Sharma, J. A. Landay, and S. Follmer, "Presenting and exploring challenges in human-robot interaction design through bodystorming," *Design Thinking Research: Interrogating the Doing*, pp. 327–344, 2021.

[4] D. Porfirio, E. Fisher, A. Sauppé, A. Albarghouthi, and B. Mutlu, "Bodystorming human-robot interactions," in *proceedings of the 32nd annual ACM symposium on user Interface software and technology*, 2019, pp. 479–491.

[5] P. Alves-Oliveira, P. Arriaga, A. Paiva, and G. Hoffman, "Children as robot designers," in *Proceedings of the 2021 ACM/IEEE International Conference on Human-Robot Interaction*, 2021, pp. 399–408.

[6] H. Pelikan, D. Porfirio, and K. Winkle, "Designing better human-robot interactions through enactment, engagement, and reflection," in *Proceedings of the CUI @ HRI Workshop*, 2023.

[7] E. Márquez Segura, L. Turmo Vidal, A. Rostami, and A. Waern, "Embodied sketching," in *Proc. CHI Conference on Human Factors in Computing Systems*, 2016.

[8] J. Blomkvist and S. Holmlid, "Service prototyping according to service design practitioners," in *xchanging knowledge, Linköping*, 2010.

[9] E. Dertien, R. Van Delden, and D. Reidsma, "Improvisation theatre as hri simulation tool," in *Proc. Int'l Conf. on Movement and Computing*, 2024, pp. 1–8.

[10] T. Williams, "Introduction to human-robot interaction: A multi-perspective introductory course," in *Proc. HRI WS on Designing an Intro to HRI Course*, 2024.

[11] J. M. Vega-Cebrián, E. Márquez Segura, L. Turmo Vidal, O. Valdiviezo-Hernández, A. Waern, R. Van Delden, J. Weijdom, L. Elbæk, R. V. Andersen, S. S. Lekbo *et al.*, "Design resources in movement-based design methods: a practice-based characterization," in *Proceedings of the 2023 ACM Designing Interactive Systems Conference*, 2023, pp. 871–888.

[12] C. Burns, E. Dishman, W. Verplank, and B. Lassiter, "Actors, hairdos & videotape—informance design," in *Conference companion on Human factors in computing systems*, 1994, pp. 119–120.

[13] K. T. Simsarian, "Take it to the next stage: the roles of role playing in the design process," in *CHI'03 extended abstracts on Human factors in computing systems*, 2003, pp. 1012–1013.

[14] S. Elbeleidy, A. Bejarano, and T. Williams, "A preliminary multi-level service blueprint of end-user development in teleoperated socially assistive robots," in *HRI Workshop on End-User Development for Human-Robot Interaction (EUD4HRI)*, 2024.

[15] K. Winkle, D. McMillan, M. Arnelid, K. Harrison, M. Balaam, E. Johnson, and I. Leite, "Feminist human-robot interaction: Disentangling power, principles and practice for better, more ethical HRI," in *Proceedings of the ACM/IEEE International Conference on Human-Robot Interaction*, 2023, pp. 72–82.

[16] I. A. Troughton, H. von Kentzinsky, M. Bleeker, and K. Baraka, ""improvisation$\neq$ randomness": a study on playful rule-based human-robot interactions," in *2023 32nd IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. IEEE, 2023, pp. 52–59.

[17] A. Fallatah, J. Urann, and H. Knight, "The robot show must go on: Effective responses to robot failures," in *2019 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*. IEEE, 2019, pp. 325–332.

[18] J. Li, A. Cuadra, B. Mok, B. Reeves, J. Kaye, and W. Ju, "Communicating dominance in a nonanthropomorphic robot using locomotion," *ACM Transactions on Human-Robot Interaction (THRI)*, vol. 8, no. 1, pp. 1–14, 2019.

[19] J. A. Greer, "Method and improvisation: Theatre arts performance techniques to further hri in social and affective robots," in *2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*. IEEE, 2017, pp. 1255–1260.

[20] N. Fields, L. Xu, J. Greer, and E. Murphy, "Shall i compare thee… to a robot? an exploratory pilot study using participatory arts and social robotics to improve psychological well-being in later life," *Aging & mental health*, vol. 25, no. 3, pp. 575–584, 2021.

[21] J. A. Greer, "Promoting theatre methodology for expressive robot movement and behavior," in *2019 IEEE International Conference on Humanized Computing and Communication (HCC)*. IEEE, 2019, pp. 114–117.

[22] E. Jochum, E. Vlachos, A. Christoffersen, S. G. Nielsen, I. A. Hameed, and Z.-H. Tan, "Using theatre to study interaction with care robots," *International Journal of Social Robotics*, vol. 8, pp. 457–470, 2016.

[23] J. Rond, A. Sanchez, J. Berger, and H. Knight, "Improv with robots: creativity, inspiration, co-performance," in *2019 28th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. IEEE, 2019, pp. 1–8.

[24] T. R. Dudeck and C. McClure, *Applied improvisation: leading, collaborating, and creating beyond the theatre*. Bloomsbury Publishing, 2018.

[25] K. Johnstone, *Impro for storytellers*. Routledge, 2014.

[26] D. Schwenke, M. Dshemuchadse, L. Rasehorn, D. Klarhölter, and S. Scherbaum, "Improv to improve: The impact of improvisational theater on creativity, acceptance, and psychological well-being," *Journal of Creativity in Mental Health*, vol. 16, no. 1, pp. 31–48, 2021.

[27] P. Felsman, S. Gunawardena, and C. M. Seifert, "Improv experience promotes divergent thinking, uncertainty tolerance, and affective well-being," *Thinking Skills and Creativity*, vol. 35, 2020.

[28] L. Berkemeyer, "Unveiling the transformative power of improvisational theatre: Effects of training improvisational theatre on creative self-efficacy and self-esteem," 2024, Preliminary results presented at the Annual Conference of the Applied Improvisation Network.

[29] J.-P. Pelletier, "Production d'un scénario pédagogique de formation composé d'exercices d'improvisation visant le développement de la compétence en gestion de classe dans la phase de contrôle durant l'action chez des stagiaires en enseignement secondaire," 2017.

[30] J. J. Gibson, *The ecological approach to visual perception: classic edition*. Psychology press, 2014.

[31] D. V. Lu and W. D. Smart, "Human-robot interactions as theatre," in *RO-MAN*, 2011.

[32] H. H. Clark and K. Fischer, "Social robots as depictions of social agents," *Behavioral and Brain Sciences*, vol. 46, 2023.

[33] M. Scheutz, T. Williams, E. Krause, B. Oosterveld, V. Sarathy, and T. Frasca, "An overview of the distributed integrated cognition affect and reflection diarc architecture," in *Cognitive Architectures*, 2018.

[34] C. Y. Kim, C. P. Lee, and B. Mutlu, "Understanding large-language model (llm)-powered human-robot interaction," in *Proceedings of the 2024 ACM/IEEE International Conference on Human-Robot Interaction*, 2024, pp. 371–380.

[35] T. Williams, C. Matuszek, R. Mead, and N. Depalma, "Scarecrows in Oz: the use of Large Language Models in HRI," *ACM Trans. on Human-Robot Int'n*, 2024.

[36] D. Gouaillier, V. Hugel, P. Blazevic, C. Kilner, J. Monceaux, P. Lafourcade, B. Marnier, J. Serre, and B. Maisonnier, "The NAO humanoid: a combination of performance and affordability," *CoRR abs/0807.3223*, 2008.

[37] H. P. Grice, "Logic and conversation," *Syntax and semantics*, vol. 3, pp. 43–58, 1975.

[38] B. Mutlu, J. Forlizzi, and J. Hodgins, "A storytelling robot: Modeling and evaluation of human-like gaze behavior," in *2006 6th IEEE-RAS International Conference on Humanoid Robots*. IEEE, 2006, pp. 518–523.

[39] C.-M. Huang, M. Cakmak, and B. Mutlu, "Adaptive coordination strategies for human-robot handovers." in *Robotics: science and systems*, vol. 11. Rome, Italy, 2015, pp. 1–10.

[40] M. L. Lupetti, C. Zaga, N. Cila, S. Šabanović, and M. F. Jung, *Designing Interactions with Robots: Methods and Perspectives*. CRC Press, 2024.

[41] J. Dörrenbächer, D. Löffler, and M. Hassenzahl, "Becoming a robot-overcoming anthropomorphism with techno-mimesis," in *Proceedings of the 2020 CHI conference on human factors in computing systems*, 2020, pp. 1–12.

[42] F. Correia, I. Neto, M. Fortes-Ferreira, D. Oogjes, and T. Almeida, "More-than-human perspective on the robomorphism paradigm," in *Companion of the 2024 ACM/IEEE International Conference on Human-Robot Interaction*, 2024, pp. 11–19.