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Designing Technology for Inclusive Play

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Abstract

Designing Technology for Inclusive Play

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Inclusion is an approach, commonly known within education, in which individuals with and without disabilities meaningfully and equitably participate in the same setting. For children, inclusive programs support the development of important social and emotional skills, like empathy and appreciation for human diversity. Within early childhood inclusive programs, supporting play between children with and without disabilities enables young children to naturally learn how to, for example, communicate, cooperate, make and maintain friendships, and take different perspectives. This play between children with diverse abilities and needs is known as *inclusive play*.

While researchers in other fields have worked to understand how to promote opportunities for children with disabilities to play with their peers in inclusive settings, there is less research in human-computer interaction that works to design and study technologies that promote collaborative play between children with and without disabilities. In this dissertation, I research how technology might be designed to support young children with diverse abilities and needs in playing together, inclusively.

Here, I integrate theories and methods from design, human-computer interaction, early childhood inclusive education, and the learning sciences. First, I gained a formative understanding of the design space through design-based and ethnographic-oriented research with children, teachers, and parents. This research enabled me to unpack the attitudes, practices, and environmental factors that may have implications for technology design in this area. For example, *transparency* about disability, how all children have similarities and differences, and how all children have situated strengths and needs is pivotal in supporting children with inclusive play.

Using what I learned from this study, I designed and built a photography-based tablet application, called Incloudle, for neurotypical and neurodivergent children to play with together. I used this system as the basis of laboratory study that allowed me to investigate, in a controlled environment, the impact of specific design features on children's ability to inclusively play together. One important finding was that Incloudle's technology-enforcement (i.e., two-person face detection during picture taking) helped children, who otherwise had trouble cooperating, take photographs together that included both their faces in the frame. However, for children who did not need this additional support, technology-enforcement limited their creativity.

Drawing on the results of this study, I iterated on the design of Incloudle and added the ability for children to wirelessly print their pictures. I then used this redesigned prototype as an intervention in an inclusive kindergarten classroom for 10 weeks. Using video data I collected during the intervention, I conducted an interaction analysis of how neurodiverse groups of children collaboratively played with Incloudle, with additional support from both me and teachers, in this context. My analysis provides insight into the ways that Incloudle mediated children's interactions, connections with each other, and negotiation of their positioning in the real world to match what was seen in virtual space. Here, I argue the interactions that emerged during the intervention were evidence of children's joint learning of how to be inclusive spatially, in verbal and nonverbal communication, and in engagement with, around, and through the device.

Drawing together my findings across these three studies, I offer considerations for designing technology for inclusive play as a form of meaningful participation and learning among children with and without disabilities. With this work, I hope to shift how designers think about designing for diverse abilities, accessibility, and collaborative engagement to help create and shape a more equitable, inclusive world.

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DEDICATION

To my grandfather, Marty Schultz.

Chapter 1. INTRODUCTION

Inclusion is an approach, commonly known within education, in which individuals with and without disabilities meaningfully and equitably participate in the same setting. Inclusive programs for children operate based on the theory that engaging children with and without disabilities will positively affect both groups (Odom & Diamond, 1998). Children with disabilities benefit from inclusive programs because they are not being implicitly told they are different, wrong, abnormal, or that they do not deserve to have the same experiences as other children. Typically developing children in inclusive programs shift their expectations and assumptions about their peers with disabilities in a positive direction (Odom & Diamond, 1998). Inclusive environments support all children to develop important social and emotional skills, including empathy and an appreciation for human diversity (Odom & Diamond, 1998). All of these beneficial outcomes “ripple through the community of the setting,” helping families of children to build inclusive relationships as well (Casey, 2005b, p. 18).

Within high quality inclusive programs for young children, play is critical. This is because play – as an active, pleasurable, and intrinsically-motivated experience (Casey, 2005b) – enables young children to naturally learn how to communicate, cooperate, make and maintain friendships, control impulses, take different perspectives, and develop other social and emotional skills (Fromberg & Bergen, 2006; Ginsburg, 2007). Accordingly, inclusive programs must provide (1) opportunities for play (and thus, learning through play) and engaging interactions among peers, and (2) developmentally appropriate materials and activities for these interactions and play (Sandall & Schwartz, 2002). This play among children with and without disabilities is known as *inclusive play* (Casey, 2005a).

While there have been major efforts within early childhood special education to modify, adapt, and otherwise allow for full co-participation in play environments for children with and without disabilities (e.g., Meyer, Rose, & Gordon, 2014; Sandall & Schwartz, 2002), there remains an opportunity to design inclusive play *technologies* for playmates with and without disabilities. To date, the Human-Computer

Interaction (HCI) community has primarily focused on research in designing play technologies for homogenous groups of children, such as groups who are all typically developing or are all part of a similar disability group (e.g., autism) (Sobel, O’Leary, & Kientz, 2015). This is despite arguments that technologies can be beneficial resources in inclusive classrooms and other settings, particularly in fostering genuine relationships (Woronko & Killoran, 2011), as means to promote learning and development (NAEYC/Fred Rogers Center, 2012), and as assistive tools for children with disabilities to participate in otherwise inaccessible activities and experiences (DEC/NAEYC, 2009).

In this dissertation, I have begun to investigate how designers might design collaborative, inclusive play technologies for children with diverse abilities and needs. In my research, I have concentrated specifically on inclusive play between neurodiverse preschool and kindergarten-aged children. I concentrate on *young children like preschoolers and kindergarteners* (i.e., ages four to six) because play is crucial for their development (Casey, 2005b). At these ages, children are also likely engaging with technologies frequently for play at home and at school (Common Sense Media, 2013; Couse & Chen, 2010; Dunn, Gray, Moffett, & Mitchell, 2018; Kabali et al., 2015; Ofcom, 2017). I focus on *neurodiversity* in regard to disability to address the more social issues—as opposed to physical considerations—of inclusion. Neurodiversity refers to neurological diversity, “a concept where neurological differences are to be recognized and respected as any other human variation” (“What is Neurodiversity?,” 2011). These differences are often labeled as cognitive, developmental, learning, social, emotional, behavioral, or other similar disabilities or disorders (Armstrong, 2010). Within neurodiverse groups of people, some are *neurodivergent* individuals (i.e., labeled with said disabilities or disorders) and others may be *neurotypical* individuals (i.e., neurologically typical or not labeled with said disabilities or disorders). When I refer to *neurodiverse children* in this dissertation, I specifically mean groups of neurodivergent children *and* neurotypical children. Focusing on neurodiversity in my work does not exclude physical disability nor does it supplant the criticality of creating physically accessible technologies for successful inclusion. Rather, by concentrating on, for example, matters of behavior and acceptance, my hope is to build on prior notions of and work in accessibility and inclusion in

early childhood inclusive education and the HCI communities, as these communities have already contributed key concepts and innovations regarding accommodations and adaptations for children with physical and sensory impairments to participate in otherwise inaccessible contexts (e.g., Brederode, Markopoulos, Gielen, Vermeeren, & Ridder, 2005; Ibrahim, Vasalou, & Clarke, 2018; Milne & Ladner, 2018; More & Travers, 2012; Sadao & Robinson, 2010).

Toward matters of equitable, meaningful participation, the goal of this research is to utilize an integrative approach to understand how technology might be designed to support young neurodiverse children with inclusive play.

1.1 RESEARCH QUESTIONS

This dissertation examines the current and potential ways that technology might support (or inhibit) neurodiverse children in playing together. Specifically, in my work, I aimed to answer four interrelated research questions:

- RQ1.** How do adults facilitate and children currently engage in inclusive play?
- RQ2.** What currently acts as barriers to inclusive play?
- RQ3.** How do specific technology design features (i.e., enforcement for cooperation, character-based content, and joint digital “selfie” photography) directly support neurodivergent and neurotypical children with inclusive play together in the short-term?
- RQ4.** How do interactions between neurodiverse children, technology, and adults shape inclusive play in a formal learning environment?

To answer RQ1 and RQ2, I integrated qualitative and design research methods to explore the current design space of inclusive play with children, teachers, and parents. This foundational research enabled me to unpack the attitudes, practices, and environmental factors that may have implications for technology

design in this area. Using what I learned in answering RQ1 and RQ2, I designed and built an interactive tablet application for neurodiverse children to play with together (Includle 1.0). I used this application as the basis of a within-subjects mixed-methods laboratory study that allowed me to investigate RQ3. The lab investigation specifically addressed examining technology-enforced cooperation, character-based content, and joint digital photography, as they related to Includle 1.0. Drawing on the results of this study – which evaluated aspects of the first prototype of Includle on a smaller scale in a controlled environment, I redesigned the system to be a more functional prototype (Includle 2.0). To answer RQ4, I used this redesigned prototype as an intervention in an inclusive classroom for 10 weeks. Using video data from the intervention, I conducted an interaction analysis of how pairs of neurodivergent and neurotypical children collaboratively played with Includle 2.0, with additional support from both me and teachers, in this context. All of this work, in addressing RQ1-RQ4, offers insight into the design question of how we might design and *not* design joint inclusive play technology for neurodiverse children. Table 1-1 shows how each of the studies I conducted addressed my research questions.

Table 1-1. How my dissertation studies address my research questions.

	Foundational exploration of inclusive play	Lab study with Includle 1.0	Classroom intervention with Includle 2.0
RQ1. How do adults facilitate and children currently engage in inclusive play?	X		
RQ2. What currently acts as barriers to inclusive play?	X		
RQ3. How do specific technology design features (i.e., enforcement for cooperation, character-based content, and joint digital “selfie” photography) directly support neurodivergent and neurotypical children with inclusive play together in the short-term?		X	
RQ4. How do interactions between neurodiverse children, technology, and adults shape inclusive play in a formal learning environment?			X

1.2 CONTRIBUTIONS

My dissertation presents three main types of contributions—empirical, artifact, and theoretical contributions. These specific contributions are as follows:

- A generative, empirical understanding of the current state of inclusive play among neurodiverse children that could inform technology design in this area.
- Generative, empirical understandings of how neurodiverse children co-engage/co-play inclusively on a tablet in both controlled and natural settings.
- An artifact (Incloudle) whose purpose is to “facilitate new insights” and “compel new possible futures” (Wobbrock & Kientz, 2016, p. 40). In this case, Incloudle embeds in its design an understanding of ‘inclusion’ and what ‘inclusive technology’ might engender or restrict for young children with diverse abilities and needs.
- A theoretical contribution of how designers can design technologies for inclusive play, specifically reflecting on photography, physical pictures, technology-enforcement for cooperation, and characters who prompt social-emotional learning-focused dialogues.
- A theoretical contribution by introducing the concept of inclusive joint media engagement – when people with and without disabilities co-use digital media or technology together – and offering conditions that support children’s productive inclusive co-engagement with new media.

With these contributions, I aim to change how the field of HCI thinks about both collaborative and accessible technology design, expanding these notions to consider inclusion as continual reflection on equity and meaningful co-participation.

1.3 DISSERTATION OVERVIEW

My dissertation is presented in seven chapters.

In Chapter 2, *Theoretical Foundations & Related Work*, I describe the theoretical underpinnings of my thesis and summarize related literature. My research incorporates theory from disability studies and early childhood inclusive education with learning theories, like social and play-based learning. This chapter also discusses ecological systems frameworks and theories of interaction, which also act as foundational for this work. Overall, I emphasize the aspects of these theories that shaped how I conducted my studies and analyses and how I designed Includle 1.0 and 2.0. After discussing theory, I then review related work in three major fields most related to inclusive play: psychology, education, and human-computer interaction. This literature covers empirical investigations concerning inclusion and play, joint media engagement and cooperative play technologies, and designing for children with disabilities.

Chapter 3, *The Design Space of Inclusive Play*, details the formative research I conducted to gain a foundational understanding of inclusive play, with and without technology, that could potentially inform technology design in this area. I report on the findings of ethnographic-oriented methods (observations, interviews, qualitative surveys) and design workshops with children, teachers, and parents.

Chapter 4, *Includle 1.0: Designing & Evaluating an Interactive App for Neurodiverse Children*, presents the first prototype I developed based on my formative work, Includle 1.0. Here, I review the laboratory study I conducted with 8 pairs of neurodivergent and neurotypical children to evaluate the impact of Includle 1.0 and its specific design features – i.e., its ability to enforce cooperation and how it presented content and prompted children to discuss social and emotional learning topics – on their play.

Chapter 5, *Includle 2.0: Technology for Inclusive Play in a Kindergarten Classroom*, presents the redesign of Includle 1.0 as Includle 2.0. I describe how I used this new, more functional prototype as an intervention in a real inclusive kindergarten classroom over a ten-week period. By conducting a deep

micro-analyses of how neurodiverse pairs of children co-played with Includle 2.0, I detail the interactions between neurodiverse children, Includle 2.0, and adults. I discuss how Includle, in turn, shapes what it “means” to be equitable and inclusive from different perspectives and acts as a coordinative artifact for learning.

Finally, in Chapter 6, Discussion, I draw all my findings together to explain how this work informs how designers might design technology for inclusive play and introduce the concept of inclusive joint media engagement. I summarize the contributions and offer opportunities for future work.

Chapter 2. THEORETICAL FOUNDATIONS & RELATED WORK

Overall, the theoretical foundations of this work are grounded in three main areas: disability studies, learning and development theories, and theories of interaction. Utilizing these theoretical perspectives allowed me to consider the lived experiences of people with disabilities, how learning may happen with and around technology, and the ways in which social and material things mutually constitute each other through interaction. In this chapter, I first describe (1) what it means to take a disability studies perspective and (2) the concept of inclusion in which people with and without disabilities meaningfully participate in the same setting. Then, I go over learning theories, such as the importance of social interactions and play for learning (e.g., Vygotsky, 1978), the learning benefits of collaborative new media use (Takeuchi & Stevens, 2011), and endogenous notions of learning (Stevens, 2010). I also discuss theories of social ecologies (Bronfenbrenner, 1992; Cole & Consortium, 2006) and theories of interaction (Goodwin, 2000; Jordan & Henderson, 1995; Norris, 2004) underpinning my work.

In this chapter, I also summarize related research in three major fields related to inclusive play: psychology, education, and human-computer interaction. The HCI research specifically concerns technologies for cooperative engagement and/or play, among groups of neurodivergent children or groups of neurotypical children, and involves both designing such technologies and studying this technology use as it naturally occurs or as design interventions.

2.1 DISABILITY STUDIES & HOLISTIC MODEL OF DISABILITY

Disability Studies is an interdisciplinary field focused on examining disability from various perspectives, such as history, theory, policy, ethics, and more (Linton, 1998). Along with the disability rights movement, the discipline of Disability Studies shifted the conceptualization of disability as a medical issue to a social one (Rothman, 2018b). With the medical model, disability is viewed as a derivation from the “norm,”

indicating a lack of function (Rothman, 2018b). This model purports that people with disabilities can be treated, trained, rehabilitated, or cured of disability to become “normal,” and in instances when medicine cannot fix the “problem,” disabled individuals are considered to be flawed permanently (Rothman, 2018b). The medical model led to the development of specialized services in specialized settings (Rothman, 2018b).

Alternatively, the social model of disability views society (i.e., the environment, context, culture, etc.) as what creates disability by defining what is considered normal and by structuring the environment in ways that are inaccessible (Rothman, 2018b). Instead of people with disabilities needing to change, under this paradigm, the environment should be adapted to meet the needs of people (Rothman, 2018b). Moreover, control is placed within the hands of people with disabilities, their family, and friends instead of medical professionals (Rothman, 2018b).

Later, Disability Studies scholars developed an alternative, holistic or non-reductionist model of disability that emphasizes an individual’s unique lived experiences (Oliver, 2013; Paterson & Hughes, 1999; Shakespeare, 2013; Shakespeare & Watson, 2001). Within this paradigm, experiences cannot be fully understood without taking into account the medical needs of impairments and the ways in which society shapes how disabled individuals encounter the world (Oliver, 2013; Shakespeare, 2013; Shakespeare & Watson, 2001). Rather, impairment, disability, illness, functional limitations, inaccessibility, ableism and others matters are distinct yet complementary issues (Pinder, 1996).

Intertwined with Disability Studies and this holistic or non-reductionist model of disability is the right for disabled people to be able to access and meaningfully participate in settings and experiences, just as their nondisabled counterparts do. Disability rights advocates and people with disabilities have fought for *inclusivity* in our society, which have led to U.S. policies and laws, requiring, for example, sidewalks and bathrooms to be accessible and for students with disabilities to have the same educational opportunities as students without them (Rothman, 2018a). This concept of inclusivity is particularly important for my dissertation work. When referring to the term ‘inclusive’ in my research, I specifically align with *inclusion*

from the field of education. Here, inclusion is an approach when students with and without disabilities participate in the same setting (Odom & Diamond, 1998).

A Disability Studies lens and non-reductionist model of disability frame my research for designing inclusive play technologies for children. Mankoff, Hayes, and Kasnitz (2010) emphasize that assistive technology researchers must understand the nuances of different approaches (e.g., how physical pain may be best understood with medical models, social anguish with critical models, structural inequity with ecological models, etc.) when designing for disability. Using these perspectives, I can see how technology has the ability to reify power, balance it, or otherwise turn the tables (Mankoff et al., 2010). I can also see how it can still disempower, exclude, and disable people (Mankoff et al., 2010). Additionally, with this framing, technology can be constructed using a bottom-up approach using a cultural construction of disability to understand what individuals—including children—with disabilities deem important to them (Mankoff et al., 2010). This changes how designers might design assistive technologies or technologies for people with disabilities. By doing research this way, we may avoid creating technologies that uptake an “ableist view” by attempting to make disabled individuals communicate, act, behave, or think like non-disabled people (Mankoff et al., 2010).

Frauenberger (2015b, 2015a) has also introduced newer notions of designing technology for disability by taking into account a critical realist (Collier, 1994) perspective of disability. Instead of only focusing on therapeutic, interventionist, and pragmatic uses for technology for neurodiversity, with this non-reductionist view, technology can scaffold and mediate interactions and empower individuals with disabilities (Frauenberger, 2015b). He claims that if we want to address the needs and desires of children with disabilities beyond “mitigating deficits,” “we need to shift our attention toward a more holistic notion of well-being, empowerment, and the scaffolding of positive experiences” (Frauenberger, 2015b, p. 58). Along these same lines, Pullin (2009, p. 45) believes “design[ing] for disability would benefit from a better balance of [the] complementary approaches” of engineering/medicine (i.e., problem-solving perspectives) and design (i.e., more creative, exploratory, or open-ended efforts).

Following Mankoff et al. (2010), Frauenberger (2015b, 2015a), and Pullin (2009), I take an integrative exploratory approach to my research in the domain of designing for inclusive play. I designed, considered the experiences of multiple actors, and engaged in constant reflection in this multi-faceted and complex situation. I began my research by exploring the design space and iteratively designing while documenting and reflecting on the process. I carried out lab and field interventions with children with and without disabilities since my design must address the needs of both play partners (i.e., what Pullin (2009) calls “resonant design”). Ultimately, using an integrative methodology prompted me to think beyond one perspective (Frauenberger, 2015a; Pullin, 2009) and explore this design space from complementary angles.

2.2 DESIGNING INCLUSIVE LEARNING EXPERIENCES FOR CHILDREN

My research is also underpinned by the concept of *universal design for learning* (UDL). UDL is a flexible approach to making teaching and learning more equitable for all children. This ensures that learners with diverse abilities and needs all reach their learning potentials. Mainly used in more formal educational settings and utilized in inclusive settings with diverse learners, the framework involves three core principles: (1) provide multiple means of engagement, (2) provide multiple means of representation, and (3) provide multiple means of action and expression (Meyer et al., 2014). Providing multiple means of engagement connects to learners’ individual interests, motivates them, and ensures that they can “find a way into the learning experience” and then remain resilient when facing challenges (Meyer et al., 2014, p. 52). By providing multiple means of representation, learners have more options for comprehension and perception, enabling them to acquire new knowledge and information (Meyer et al., 2014). Finally, providing multiple means of action and expression allows learners to use various tools, strategies, technologies, and other scaffolds to act in the world and express themselves (Meyer et al., 2014).

Along these same lines, Sandall and Schwartz (2002) offer a comprehensive framework of strategies to support positive peer interactions in the inclusive classroom. In their *Building Blocks* framework, there are

four main 'building blocks' that can be utilized to facilitate friendships and social relationships: child-focused instructional strategies (CFIS), embedded learning opportunities (ELOs), curriculum modifications (CMs), and providing a high quality early childhood environment. While CFIS concern explicit teaching of concepts, the other three offer ways to modify and plan activities, materials, and the environment such that children are supported and encouraged to play and socialize with each other.

2.3 LEARNING THEORIES

2.3.1 *Social and Play-based Learning*

Foundational to my design work and research is the theory that social interactions and play are crucial for learning. Vygotsky's (1978) social learning theory posits that engagement and information from the external world are transformed and internalized through language. Language is both a symbolic form of communication and a cultural tool to transmit information and knowledge. When children play, they develop both language and understanding of the external world. During play, children are constantly in dialogue between themselves and others around them. This internal and external dialogue becomes a form of "inner speech" used later in adulthood. Children begin their learning with social interactions with their parents, often observing behavior and listening to their speech. Later, children begin to mimic these interactions through speech and behavior.

Children's social play soon begins another aspect of social learning (Vygotsky, 1978). This play allows children to imitate roles, try out language, and transition from external regulation to internal regulation. In addition to language development and academically-focused learning, inclusive play in particular allows children to gain authentic understandings of people who have both similarities and differences; develop positive attitudes and social-emotional skills, like empathy, tolerance, and acceptance of other perspectives; and build a stronger sense of self and self-esteem (Casey, 2005b, pp. 18-19).

I frame my understanding and design of technologies for inclusive play according these theories of social learning and the benefits of inclusive play. Using these theories allows me to ground my research in the

notion that inclusive play opportunities supported by technology are rich spaces for learning and development.

2.3.2 *Adult Scaffolding*

Also underpinning my work are the concepts of Vygotsky's (1980) zone of proximal development (ZPD) and scaffolding (Wood, Bruner, & Ross, 1976). The zone of proximal development signifies the difference in what learners can and cannot do without assistance. Therefore, in their ZPD, children or learners are able to carry out relevant tasks with appropriate guidance. The theory of scaffolding, introduced by Wood, Bruner, and Ross (1976), refers to this guidance—the process of enabling a child or novice to achieve a goal or carry out a task successfully. When scaffolding children's learning, an adult or more knowledgeable person controls "elements of the task that are initially beyond the learner's capability, thus permitting him [or her] to concentrate upon and complete only those elements that are within his [or her] range of competence" (Wood et al., 1976, p. 90).

During inclusive play, adults have more specific roles in scaffolding for both children with and without disabilities. This involves facilitating communication, modelling inclusive behavior, intervening, and being a participant alongside children during play (Casey, 2005b). As participants in children's play, adults can "gently hold the play together for a child or group of children when it might otherwise come apart" (Casey, 2005b, p. 62). Specifically, adult scaffolding in this context can involve providing a role for the child with a disability, modelling play, giving explicit instructions, and pairing up with children (Casey, 2005b). Moreover, adults can facilitate communication in this context by expanding, reinterpreting, repeating, simplifying, slowing down, and bridging communication (Casey, 2005b).

By taking into account scaffolding and the specific aspects of scaffolding necessary for inclusive play, I was able to approach the design and study of technology with the significant understanding that technology use among neurodiverse children cannot necessarily happen successfully without adult support.

2.3.3 *Joint Media Engagement*

Collaborative engagement with technology, also known as joint media engagement (JME), is particularly important when designing for children and learning. This is because by jointly viewing, playing, searching, reading, contributing to, and creating with digital media, children have the context and resources to create meaningful connections among representations, interests, and experiences (Takeuchi & Stevens, 2011). Through JME, participants can make sense and meaning together in a particular situation and for future situations (Stevens & Penuel, 2010). Thus, when children jointly engage with digital media with others, regardless of if that digital media is traditionally 'educational' or not, they learn (Takeuchi & Stevens, 2011). This learning is not only in regard to the media being consumed but also involves social, cognitive, and emotional benefits (Takeuchi & Stevens, 2011).

Drawing from past research and development, Takeuchi and Stevens (2011) describe six conditions that lead to productive JME; these conditions are "ideals" and all of them do not have to exist in a JME experience simultaneously for that experience to lead to learning and development. The six conditions are as follows:

1. *Mutual engagement*: Those engaged should be motivated to participate equally; both find it challenging and/or appealing.
2. *Dialogic inquiry*: Engagement should inspire reciprocal, contingent communication and/or collaboration to make meaning of situations.
3. *Co-creation*: Through co-use, people can create shared understandings and/or artifacts, which ground communication and learning.
4. *Boundary crossing*: Engagement spans times and settings, stimulated by past experiences and inspiring future activities.

5. *Intention to develop*: At least one person should intend to grow through participation (e.g., through leveling up in a game or by learning).
6. *Focus on content, not control*: Technical and user interface features do not distract or take away from partners' interactions or their interactions with the content.

I ground my design and research on the theoretical learning benefits of JME and the conditions for productive JME that Takeuchi and Stevens (2011) offer. Still, moving forward, Takeuchi and Stevens (2011, p. 55) note an important area for future research is studying “the qualities of media design and deliberate use that encourage productive JME,” particularly in non-traditional families and settings. Following this call for research, I help build knowledge about what design can do to foster inclusive play as a form of productive JME between neurodiverse children.

2.3.4 *Endogenous Science of Learning & Learning as a Member's Phenomenon (LAMP)*

Concerning the science of learning, Stevens (2010) argues for viewing learning from an *endogenous* perspective, as opposed to an *exogenous* one. An *exogenous* approach to learning, which most people are familiar with, examines learning “from without” or from perspectives “outside” the learner. When learning is examined exogenously, learners are often pre- and post-tested, according to specific dimensions or outcomes deemed important by authorities beyond the learners themselves.

Opposingly, an *endogenous* approach to learning examines learning “from within” or from the perspectives of the learners. From this perspective, learning is “co-constructed in and across events between people, and between people and things, in everyday life” (Stevens, 2010, p. 83). In this way, *learning is a members' phenomenon* (LAMP). Then, learning can be analyzed at the level of interactional events to establish that “an activity is for its participants a learning event” (Stevens, 2010, p. 85). When learning is approached as a members' phenomenon, researchers can argue learning is happening by showing and interpreting how participants initiate, orient to, and sustain an interaction as a learning event, including the interactional resources they use to do so.

In my research, I approach learning as a members' phenomenon for two main reasons, as articulated by Stevens (2010). First, an exogenous approach, as an "administrative science" concerned with capacities chosen by "normative institutional forces," is "ill-suited to capture learning events that emerge in the practical concerns of everyday life" (Stevens, 2010, p. 83). Second, I, like Stevens, believe "children deserve the right to find, see, and make their own learning" (Stevens, 2010, pp. 95-96). By approaching LAMP, I analyze learning, participation, and interaction from an endogenous perspective as well.

2.4 ECOLOGICAL SYSTEMS THEORY

Drawing on the work of Michael Cole (2006), the theoretical underpinnings of my dissertation relate to the social ecologies of technology use among neurodiverse children. This foundation leads me to "think simultaneously about the social organization of activity, the various tools used to carry out the various tasks..., social roles, modes of participation, and the relation of the activity to its context" (Cole & Distributive Literacy Consortium, 2006, p. 8). In this way, I, like Cole (2006), am drawing on Vygotsky (1980), who turns toward both culture and tools as having roles in learning and development.

First, it is important to understand Bronfenbrenner's ecological systems theory, which generally states that the entire ecological system in which growth occurs influences human development (Bronfenbrenner, 1992). This ecological system is represented as concentric circles of subsystems, with the individual (here, the child) placed at the center (Figure 2-1). Placing emphasis on social and cultural context, this model shows how the subsystems affect the child directly or indirectly and influence each other as well. For example, with this model, a child's age impacts her development while family, school, local politics, and cultural ideologies affect her development (and each other) too. As such, in my work, I have examined not only the children who are involved in inclusive play but also the systems/contexts (including the cultural attitudes) that impact the children and their play.

Building on this ecological model in their ethnographic study of digital youth, Ito et al. (2009) bring in new media practice as part of the broader social ecology, yet focus on the 'social turn' in literacy studies, new

media studies, learning theories, and childhood studies for their research. Likewise, Cole (2006) uses a “social-ecological concept of context” to design and evaluate his after-school program that utilizes information technologies with undergraduate student support to promote learning called the Fifth Dimension. Instead of one individual being at the center of this model (like in Figure 2-1), the child, undergraduate student, and tasks are placed at the center (Figure 2-2), changing the unit of analysis from one individual to “the interactions of children and undergraduates as they engage in joint activities with computers and games at a specific time, in a specific place, and as part of an inclusive setting” (Cole & Consortium, 2006, p. 16). However, Cole (2006) also realizes the limitations of only considering context and social organization when designing and organizing the Fifth Dimension activities, some of which are constructed around technological artifacts. Therefore, in this work, I utilize a socio-material perspective that acknowledges the role of computational artifacts, in addition to humans, in shaping ongoing action/interaction (Bjorn & Osterlund, 2014), which I explain further in the next section.

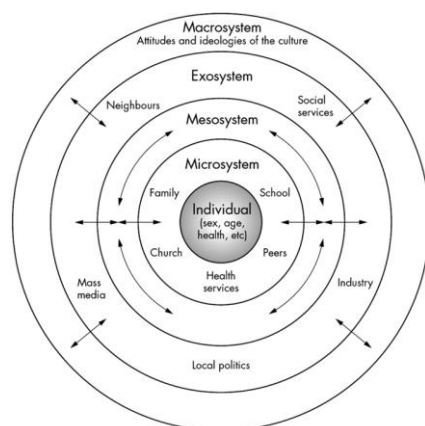


Figure 2-1. Model of Bronfenbrenner's (1992) ecological systems theory (McLaren & Hawe, 2005, p. 10).

Figure 2.1 A Bronfenbrenner-Style Picture of a Child and Undergraduate in a Fifth Dimension Activity System

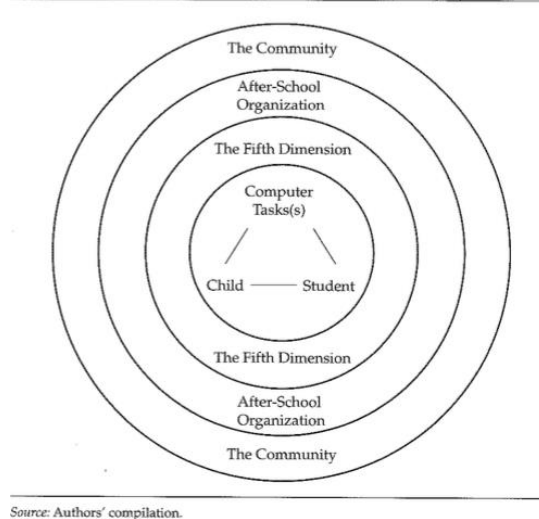


Figure 2-2. Cole's (2006, p. 17) 'social-ecological' concept of context for the after-school program called the Fifth Dimension.

2.5 THEORIES OF (INTER)ACTION

While Cole (2006) shifted units of analyses from the individual to interactions between people in a specific setting, I utilize theories of action and interaction, which include technology or other artifacts as central to interaction as well. I draw on theories from interaction analysis (Jordan & Henderson, 1995), including multimodal interaction (Norris, 2004) and how situated, embodied action is "built" upon a myriad of semiotic resources, including the material (Goodwin, 2000).

At the foundation of my dissertation is the assumption that all interactions are multimodal (Norris, 2004); people draw interactional meaning from "a multiplicity of communicative modes" (Norris, 2004, p. 2), including language, gesture, gaze, and materials. Moreover, I take up the underlying assumption of interaction analysis that "artifacts and technologies set up a social field within which certain activities become very likely, others possible, and still others very improbable or impossible" (Jordan & Henderson, 1995, p. 41). In this way, my analytical processes could lead to an understanding of what kinds of interactions a technological artifact both engenders and restricts. For instance, while interactional practices engendered (or even enforced) by a technology could, in theory, be in line with inclusive classroom goals

of equitable participation, they could be at odds with normative (cooperative or uncooperative) interactions of children *outside* of the system's use.

With this orientation, it follows that my theoretical framing for this work also employs Goodwin's (2000) arguments that material structures can provide semiotic structure that make action possible. The structure of play with technology is something children can "explicitly [orient] to, and [draw] upon as a resource for, the constitution of action" (Goodwin, 2000, p. 1496). Here, human action is a series of 'entanglements' (Ingold, 2007) that involve "locally relevant webs of semiotic and social relationships" (Goodwin, 2013, p. 16). Participation structures that occur within co-play become "ongoing contingent accomplishment[s]" with participants' "reflexive awareness" (Goodwin, 2000, p. 1503) of each other's co-participation with a rich set of semiotic resources (i.e., gesture, posture, talk, the technology design features, etc.). In this case, technology can be seen as an interactive material that provides "a framework for building classes of action" (Goodwin, 2000, p. 1516), like a hopscotch grid for young girls playing hopscotch and a Munsell color chart for archeologists classifying the color of dirt (i.e., Goodwin's (2000) examples).

2.6 PSYCHOLOGY & EDUCATION RESEARCH IN INCLUSIVE PLAY

In terms of related research, scholars in psychology and education continue to work toward creating and identifying effective evidence-based practices to promote social interactions and play among young children in inclusive environments (Odom & Diamond, 1998; Woronko & Killoran, 2011). Researchers have examined beliefs of teachers and parents to understand their roles in friendships among children with and without disabilities (Beckman et al., 1998; Hollingsworth & Buysse, 2009). Ochs, Kremer-Sadlik, Solomon, and Sirota (2001) have extensively studied the experiences of autistic children in mainstream elementary school classrooms, as impacted by family, institutional, situational, and interactional dynamics and by typically developing students' understandings of autism (for more related work in this area, see Angell & Solomon, 2017; Ochs & Solomon, 2010; Solomon, Heritage, Yin, Maynard, & Bauman, 2015). Researchers have also tested peer-mediated, naturalistic teaching and preplanning contexts for play dates and play

groups as interventions to encourage play between young typically developing children and children with autism (DiSalvo & Oswald, 2002; Koegel, Werner, Vismara, & Koegel, 2005; Nelson, Nelson, McDonnell, & Johnston, 2007; Wolfberg, DeWitt, Young, & Nguyen, 2015); and they have developed social integration activities and social skills training interventions for young children with disabilities to promote peer interactions in natural environments (e.g., Brown, Odom, & Conroy, 2001).

However, within these disciplines, there is little to no empirical research in how technology could be utilized to connect children during inclusive play. This is despite emphasis that technologies can be beneficial resources in inclusive classrooms and other settings, particularly in fostering genuine relationships (Woronko & Killoran, 2011), as means to promote learning and development (NAEYC/Fred Rogers Center, 2012), and as assistive tools for children with disabilities to participate in otherwise inaccessible activities and experiences (DEC/NAEYC, 2009).

2.7 HCI RESEARCH IN TECHNOLOGIES FOR PLAY

At the same time, technology is becoming more and more pervasive in young children's lives, as a type of new media to play with both at home and in the classroom (Common Sense Media, 2013; Couse & Chen, 2010; Dunn et al., 2018; Kabali et al., 2015; Ofcom, 2017). As such, within Human-Computer Interaction, researchers have designed and evaluated various interactive technologies to support joint media engagement around technologies, particularly in regard to facilitating and encouraging communication, collaboration, and cooperative play between children (Hourcade, 2015). For example, interactive tabletop displays have altered how young children can engage together through augmented fantasy play (Mansor, De Angeli, & De Bruijn, 2009) and have added scaffolding and interactivity to table-based activities like puzzles and path tracking (Kammer, Dang, Steinhauf, & Groh, 2014). Tangible user interfaces have also been a natural and successful way to bring children together (Antle, Droumeva, & Ha, 2009), especially in the areas of collaborative programming (e.g., Horn, Solovey, Crouser, & Jacob, 2009; Horn, Solovey, & Jacob, 2008) and storytelling (e.g., Lu et al., 2011; Marco, Cerezo, & Baldassarri, 2013). Additionally, large

and small mobile devices have allowed children to collaboratively read and create stories (Fails, Druin, & Guha, 2010), engage in spelling games in groups (Jain, Birnholtz, Cutrell, & Balakrishnan, 2011), and share and motivate each other to complete learning activities in a classroom (Sobel, Kovacs, et al., 2017). Combined with augmented reality and cooperative problem solving, mobile games have also been able to facilitate physical coordination, physical support, and verbal instructions, clarifications, and communication between older-younger sibling pairs (Ballagas et al., 2013).

2.7.1 *Collaborative Tech for Children with Disabilities*

Regarding children with disabilities, especially those with autism spectrum disorders, HCI researchers have developed and tested interactive technologies whose goals are to help children learn social skills through cooperative and social group interactions around the technology. Farr et al. (2010; 2010) developed multiple tangible user interfaces for children with autism to play with together in an unstructured way, resulting in more collaborative and parallel play, as opposed to solitary play. Other researchers have designed and evaluated more structured play technologies that have the ability to enforce cooperation among playmates. For example, Piper et al. (2006) developed SIDES, a cooperative tabletop game they designed to help adolescents with high-functioning autism practice their group work skills, to be motivational, supportive, and increase social skills confidence. In evaluating SIDES, they found that the game's computer-enforced rules for turn-taking was important for players in this context. Similarly, Hourcade et al. (2013) studied how two-player tablet apps can encourage social interactions between 10- to 14-year-olds with autism. One of the applications they studied, called Untangle, requires children to cooperate to untangle a visual puzzle with multiple fingers so it cannot be used alone. They found this app led to significantly more supportive comments between children compared to other activities. Likewise, Boyd et al. (2015) examined how Zody, a collaborative iPad game, facilitated social skill development among 8- to 11-year-olds with autism. Zody uses various in-game elements to support collaboration. The researchers show that the app's various cooperative gestures align with the development of turn taking, compromise, empathy, joint attention, communication, and shared joy. Similarly, Battocchi et al. (2009)

showed that enforcing collaboration in their tabletop game called the Collaborative Puzzle Game led to positive effects on collaboration in pairs of typically developing boys and in pairs of boys with autism, all approximately 9-years-old. The focus of these research studies on using technology as cooperation enforcement and the success of these technological features inspired and provided the basis for my own work in investigating the impact of technology-enforced cooperation for children with more diverse sets of abilities and needs.

2.7.2 *Technologies for Inclusive Play*

There has been less work done in the field of HCI concerning inclusive technologies for children with and without disabilities. In one project, Brederode et al. (2005) developed a collaborative tangible augmented tabletop game for 8- to 14-year-old children with and without disabilities to work together against a computer opponent; they found it was successful in stimulating social interactions. Another instance, Zolyomi et al. (2017) studied how two different video-based systems for remote communication supported four boys (age 9-11) on the autism spectrum remotely play with a neurotypical playmate (age 8-13). They found that both systems (Microsoft Skype and Microsoft IllumiShare) enabled cooperative and parallel play yet sometimes constrained joint attention and perspective-taking. Additionally, Holt et al. (2014) developed various tangible and tablet-based games for children ages 7-10 with and without physical disabilities, finding that creating fully accessible cooperative games did not eliminate social barriers to inclusion. My dissertation builds on these approaches that promote inclusion, but also focuses on a younger population and considers the greater contexts in which children participate. In doing so, I aim to fill the gap in work that designs and studies inclusive, collaborative play technology within inclusive settings.

2.8 NEW MEDIA CHARACTERS & STORIES

As socially relevant, contingent, and meaningful additions to technology for learning (Calvert, Strong, Jacobs, & Conger, 2007; Horton & Richard Wohl, 1956; Krcmar, 2010; Lauricella, Gola, & Calvert, 2011), using characters to prompt interactions and promote social skill development within interactive technology

has also been explored within the HCI community, both with typically developing children and with children with disabilities.

One such example is Family Story Play, a system that promotes dialogic reading activities for very young children and their families across long distances. The system supports child engagement with remote grandparents during reading, using help from Elmo (a popular character from *Sesame Street*) (Raffle et al., 2010). Elmo provides questions and prompts to support family communication and dialogic reading goals. In a study that compared Family Story Play to book reading over Skype, children enjoyed Family Story Play overwhelmingly more because of Elmo, as they were interested and engaged with the character. His involvement also helped the grandparents focus the children's attention on the story.

Considering the effects of characters on children with disabilities, Tartaro and Cassell (2008) developed an intervention for children with social and communication disorders in which the children interacted with a virtual peer in a collaborative narrative task. Their study showed that virtual peers engage children with autism in social interactions and facilitate contingent discourse, which is important for any social communication. There have been many other studies that show the positive effects of virtual characters on supporting children with autism with their social communication skills as well (e.g., Alcorn et al., 2011; Mower, Black, Flores, Williams, & Narayanan, 2011).

There are also many commercial interactive "feelings" games that involve popular characters (e.g., Daniel Tiger, Arthur, Cleo, Buster, Clifford, Elmo) ("Feelings Games," n.d.). Led by the characters, these games allow children to interactively play to learn about and develop social and emotional skills. My research builds on this previous work by examining the use of characters in interactive "feelings" technology targeted toward pairs of neurodivergent and neurotypical children.

Chapter 3. THE DESIGN SPACE OF INCLUSIVE PLAY¹

To address the first research questions, RQ1 (*How do adults facilitate and children currently engage in inclusive play?*) and RQ2 (*What currently acts as barriers to inclusive play?*), I took an integrative exploratory approach to examining the current state of inclusive play broadly and the role of technology specifically within inclusive play. This enabled me to examine and identify the attitudes, practices, and environmental factors that may have implications for technology design in this area; this also helped me with my own design process. As part of this study, I connected prior research in early childhood inclusive education and the positive and negative experiences of teachers, parents, and children to the design of technology. This connection can help us choose where, when, and how to appropriately and thoughtfully design to support children and adults involved in inclusive play.

In this chapter, I describe the study methods I used to gain a foundational understanding of inclusive play and then detail the themes that emerged from my analysis. These themes fall into two areas: *facilitators* of inclusive play and *barriers* to inclusive play, which connect to how technology might be *appropriately* and *not appropriately* designed in this domain. Through my discussion of technology design considerations, I argue the facilitators and barriers are relevant for future technology design. Lastly, I provide a scenario with a potential design to ground my discussion. This work provides an empirically-based generative understanding of inclusive play for designers and researchers to use to develop new technologies and examine existing technologies in this space.

3.1 METHODS

To get a holistic understanding of this design space, I integrated various qualitative methods, including design ethnography, surveys, and interviews. This involved me, along with two other collaborators,

¹ Sobel, K., O'Leary, K., & Kientz, J. A. (2015, June). Maximizing children's opportunities with inclusive play: considerations for interactive technology design. In *Proceedings of the 14th International Conference on Interaction Design and Children* (pp. 39-48). ACM.

studying children directly as well as the teachers and parents who directly impact young children’s inclusive play experiences.

I primarily studied children through design ethnography and carrying out design activities in an inclusive classroom, all aimed at gaining insight into their perspectives, wants, and needs. To supplement my work with children, I conducted surveys and semi-structured interviews that gave me access to additional perspectives of teachers and parents. These methods complemented my classroom experiences and involved additional stakeholders – taking into account the experiences, needs, and attitudes of these adults was important in this context because they directly influence children’s development, relationships, and experiences (Bronfenbrenner, 1992). These methods involved a total of 101 participants; Table 3-1 provides a table of the participants to whom I refer directly in this work.

Table 3-1. Connection between participants and methods. ^αRequired participants’ children to participate in inclusive play. ^βDid not require their children to participate in inclusive play.

Participants	Participant ID	Method
Neurodivergent children	CND1 - CND2	Workshops 1 & 2
	CND3 - CND4	Workshop 3
Neurotypical children	CNT1 - CNT3	Workshops 1 & 2
	CNT4 - CNT5	Workshop 3
Inclusive classroom teachers	T1 - T4	Survey
	T5	Interview
Parents of neurodivergent children	PND1 - PND14	Survey 1 ^α
	PND15 - PND22	Interview ^α
	PND23 - PND24	Survey 2 ^β
Parents of neurotypical children	PNT1 - PNT2	Survey 1 ^α
	PNT3 - PNT4	Interview ^α
	PNT5 - PNT27	Survey 2 ^β

3.1.1 *Methods with Children: Inclusive Classroom Design Ethnography & Workshops*

As part of my design ethnography, I volunteered in two joint inclusive kindergarten classrooms that were each nearly evenly split between children with and without diagnosed disabilities. There were 18 children in one classroom and 17 in the other, but the classrooms were often combined for learning and play activities. My volunteer work as a teachers’ assistant involved helping in the classroom for approximately

70 hours over eight months in 3-3.5-hour blocks. I collected data by taking notes/jottings during classroom sessions and reflective fieldnotes after the sessions when there were particularly salient occurrences related to inclusive play. I also completed a graduate level course in Early Childhood Special Education, which provided information on theory-based and evidence-based practices in the field, which informed my volunteer work and understanding of inclusion in the classroom.

The kindergarten classes in which I volunteered are part of a well-resourced inclusive school and research center with high teacher-to-student ratios (i.e., approximately 1:5), well-qualified and supportive staff, interdisciplinary teams, and a clear focus on promoting high quality learning for children of all abilities. The school also provides support programs for parents and caregivers, so families are also engaged in their children's education. This classroom allowed me to investigate and experience how an archetype for high quality inclusive education that encourages social and emotional learning operates. (See Figure 3-1 for an image of what the inside of the classroom looked like.)



Figure 3-1. Inside the classroom, where children sat in circle together.

This classroom follows the Creative Curriculum, a research-based curriculum that provides structure and suggestions for how to implement developmentally appropriate practices in early childhood education (Dodge, Colker, & Heroman, 2002). *Developmentally appropriate practice* refers to teaching and providing care for young children based on what is typical at each age and stage of development and what is

appropriate for a child as an individual and within his or her cultural, social, familial, and other contextual circumstances. The curriculum applies major child development theories (e.g., Maslow's hierarchy of needs, Erikson's "Eight Stages of Man," Piaget's developmental stages, Vygotsky's social interactions and learning theories, Gardner's multiple intelligences, Smilansky's four types of play, and resiliency research—all as cited in Dodge et al. (2002)) to early childhood education (Dodge et al., 2002). It is important to note that the classroom's use of the Creative Curriculum has shaped my view on quality early childhood education and therefore influenced my focus on this curriculum as it applies to the research covered here.

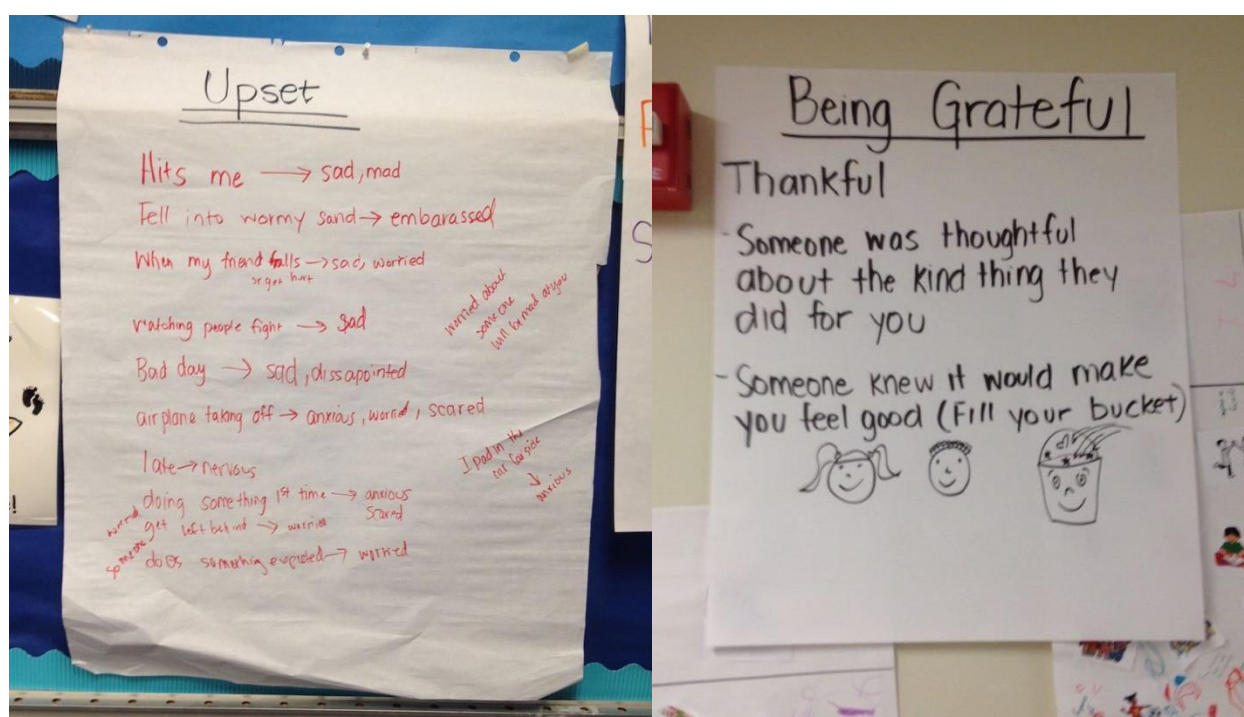


Figure 3-2. Examples of social and emotional learning discussions in the classroom. *Left:* Why you might be upset and what it feels like. *Right:* Why you might feel grateful.

Primarily, I volunteered in the classes on "Buddy Day," a day devoted to social and emotional learning (SEL). On this day, the children have large group circle (with the entire class) or two small group circles (split almost in half by learning ability) in which they learn one aspect of social and emotional intelligence (see Figure 3-2 for examples). Next, they are assigned buddies in pairs or triples, which teachers predetermine before school that day and announce in large circle. Buddies are required to play together for the remainder of the day. After buddies are announced, they move to small activities or "buddy stations,"

which they rotate through; one of these activities usually relates directly to the large circle SEL topic. Lastly, the children go to free play where they can play whatever they like in order to generalize their skills, but they must do so with their buddies. Examples of buddy/free play stations include activities such as building with blocks, reading, drawing, painting, and playing with clay.

To supplement my involvement in the classrooms, I also ran three design activities at the same school with groups of students with diverse abilities, lasting between 30 to 45 minutes each. Each session involved four to six children total, half of whom were neurodivergent (participants CND1-CND4 and CNT1-CNT5). During these workshops, we discussed the children's favorite types of toys and play activities. The children also crafted their own toys to promote cooperative play. These sessions allowed me to (1) gain more hands-on experience and detailed personal interactions with the students and (2) to understand the types of activities in which children could and wanted to engage together. I video recorded the activities and took notes during and after them.

3.1.2 *Methods with Teachers: Surveys & Interviews*

Although I was able to observe and interact with teachers in the classroom, it was often difficult to obtain their perspectives and ask questions while they were directly working with children. Therefore, to obtain a more robust understanding of educators' experiences with inclusion and with technology specifically, I recruited teachers from the aforementioned school to participate in interviews or surveys to be respectful of their busy schedules. While four kindergarten and preschool teachers answered the interview questions in a survey format (T1-T4), I interviewed one kindergarten teacher in-person (T5). The questions I asked included open-ended questions on their opinions on inclusion, play, technology, and strategies for encouraging play and other social interactions. I kept the definition of technology open-ended but included a list of examples of technology (e.g., game systems, interactive toys, tablets, mobile phones, wearables, cameras, computers, projectors, etc.) as to not limit my understanding of technologies in this context. However, teachers spoke mostly about the iPad, since it was frequently used in their classrooms. I also asked for feedback on four preliminary design ideas presented in storyboard format (developed iteratively

based on my volunteer work in the classroom and my review of related literature) for how technology could be used to teach empathy to encourage social interactions between children with and without disabilities. Survey participants were compensated with US\$10 Amazon gift certificates and the interview participant was compensated with a US\$20 Amazon gift certificate as compensation for their participation.

3.1.3 *Methods with Parents: Surveys & Interviews*

Because parents directly impact their children's development, relationships, and experiences (Bronfenbrenner, 1992), I investigated parents' perspectives on inclusive play and where they believed technology could be the most effective tools to help them, their own children, other children, and other parents with inclusive play. Again, for the surveys and interviews, I kept the definition of technology open-ended but included a list of examples.

I recruited parents with children ages 3 to 12 because I could learn from parents who had desires for and reflections on the future, current, and past experiences of their own children that would be relevant to children ages four to six. I deliberately did not recruit parents from the aforementioned inclusive school; rather, I sought more heterogeneous perspectives, especially of parents who are not supported by a state-of-the-art inclusive school. I recruited alternative perspectives via parent mailing lists, Facebook, organizations for children with disabilities, and Amazon Mechanical Turk to participate in open-ended surveys or semi-structured interviews.

I first recruited parent participants with the requirement that their children must have previously engaged in inclusive play with a child with a disability at least once. I conducted an open-ended survey (Table 3-1: Survey 1) with 16 parents whose children had participated in inclusive play dates. Only two of the sixteen had neurotypical children (PNT1-PNT2), while the others had children who were neurodivergent (PND1-PND14).

To gain additional depth, I also conducted 10 semi-structured interviews (Table 3-1: Interview) with parents, two of whom had neurotypical children (PNT3-PNT4) and eight of whom had neurodivergent children (PND15-PND22).

Finally, to get additional perspectives from parents of neurotypical children to balance the data from parents of neurodivergent children, I conducted an open-ended survey (Table 3-1: Survey 2) with 25 parents that did not require the participants' children to have participated in inclusive play. This resulted in a higher response rate of 23 parents with neurotypical children (PNT5-PNT27) and a lower number of parents with neurodivergent children (PND23-24). I asked the parents with neurotypical children additional questions concerning whether they would like their children to have more experiences with neurodivergent children.

3.1.4 *Data Analysis*

My two collaborators and I analyzed the entirety of the data using an iterative approach to qualitative coding, both inductively and deductively, to uncover consistent themes across different stakeholders and contexts (Corbin & Strauss, 2008). All interview data was transcribed, and video data was content logged (Derry et al., 2010). Initially, we coded the data inductively to identify emerging cross-cutting themes. As we reached data saturation and themes began to stabilize, we adopted a deductive coding approach. These themes represent the current state of inclusive play and technology's place within it. In the following section, I report the thematic ways in which inclusive play works well and where barriers to inclusive play remain.

3.2 RESULTS

Here, I describe the facilitators and barriers to inclusive play based on the related literature and my study data analysis. Rather than organizing the results by method, I integrate the findings by the cross-cutting themes that can help inform technology design. This is reflective of the fact that facilitators and barriers of inclusive play span across experiences among children, teachers, and parents.

3.2.1 *Facilitators of Inclusive Play*

At the foundation of a successful inclusive setting, or any childhood setting, is a safe, comfortable environment (Sandall & Schwartz, 2002). Both teachers and parents commented on the importance of a safe environment in helping their children thrive. Beyond this foundation, there are a number of things that work well currently to facilitate inclusive play. Below I go over these facilitators to inclusive play. The categories are not mutually exclusive. In fact, most draw on each other and incorporate aspects of multiple other categories. Additionally, many of these facilitators extend to enabling non-inclusive play; however, we emphasize that play among neurotypical children may not *need* these facilitators to occur, whereas they are central to inclusive play. In the discussion, I will expand on how these facilitators can help guide the design of technology for inclusive play.

3.2.1.1 Direct Support and Embedded Support

To assist children in inclusive play, adults provided a mix of direct and embedded support (Sandall & Schwartz, 2002). Within early childhood inclusive education, there are teaching strategies and curriculum modifications regarding different types of supports, like adult support, peer support, invisible support, and embedded learning opportunities (Sandall & Schwartz, 2002). Below, I discuss the ways in which we observed teachers using direct and embedded supports and the ways in which teachers and parents described these supports to facilitate inclusive play.

Direct Supports: Adults provided explicit support for play interactions among children by teaching social and emotional skills concepts directly. They also provided physical and language tools for children to use during play. The goal is for the children to generalize these skills and concepts to natural settings. In the classroom, teachers gave lessons on friendship, how one's own actions can affect other people, what particular emotions (e.g., worried) look like and feel like, what people can do in response to different feelings, and how all people are both similar and different. They taught children specific language to use during playtime, such as "a bug and a wish." This language helps children be clear by saying, "It bugs me

when..." and "I wish you would..." Teachers also taught children specific language to use during play to make sure they are being good friends to each other. For example, children "fill their buddy's bucket" when they are acting kind or "dip into their buddy's bucket" when they are not kind. This language, which comes from the children's book *Have You Filled a Bucket Today?* by Carol McCloud, allowed the children to see from others' perspectives and to understand that their actions or words can affect others.

I also observed physical tools used in the classroom such as play plans, social stories, and a Friendship Kit. Play plans are lists of play activities children create together to ensure each child gets to do her preferred play activities. Social stories are short scripts for children to follow to learn play skills, such as inviting other children to play or compromising when they do not get their way (C. A. Gray & Garand, 1993). The Friendship Kit is a physical tool that holds bandages, sticky notes, pencils, stickers, and play scripts that children can use to be good friends (Figure 3-3, Figure 3-4). Children used the Friendship Kit when they wanted to make another child feel happy or learn how to play with another friend.



Figure 3-3. Friendship kit. Closed (left) and open (right).



Figure 3-4. Guide for how to be a good friend in the Friendship Kit. (Guide text: *"We are good friends! If I see a friend that is sad or needs help I can be a good friend! If my friend is hurt or upset I can... give me a band aid, write them a note, draw them a picture, give them a sticker, ask them if they need a hug or high five. I am such a good friend!"*)

Parents of neurodivergent children also reported directly supporting their children to promote inclusive play. They do this by teaching other parents and other children about their child's disability. They also teach parents what makes their child the same as and different from other children. This is in line with findings of Ochs et al. (2001) that children with autism whose parents disclosed their children's diagnoses to their classmates had better social support in class and on the playground. For instance, one parent of a neurodivergent child (PND15) felt that one of best ways to help neurotypical children play with children with disabilities is to *"offer a safe environment where they are given info about what to expect and how to handle a situation, should it arise."* Giving direct information to children about how to play with other children is effective in facilitating the play.

Embedded Supports: Adults also provide implicit support for play interactions by embedding learning and play skills within activities. These embedded supports help children in context and in real time without teaching concepts directly. I observed teachers providing embedded support by assigning buddy pairs based on similar preferred activities, prompting interactions between children (e.g., “Tell your buddy what you are building.”) and giving positive feedback to children to reinforce pro-social behavior.

In line with literature on play and learning play skills (Fromberg & Bergen, 2006), teachers commented on how particular toys, games, and other types of play have embedded supports in them. They explained these supports promote active engagement among children, encourage social interactions, and teach play skills implicitly (e.g., board games require children to take turns; children cannot use a wagon alone; if only two pairs of scissors are available to three children during an art activity that requires cutting, then they have to share). Teachers intentionally provided these objects and activities in the class.

Some parents commented on the types of inclusive play activities they want their children to do that have embedded supports. One parent (*PND2*) mentioned that during inclusive play, children should only participate in activities that encourage interaction and avoid those that are mostly done by one person. Another (*PND16*) said her neurodivergent child and neurotypical friend “*take turns going down the slide and will ride the teeter totter together.*” The slide, which seems like an individual play structure, can become an embedded learning experience for children to practice taking turns. And, like a wagon, a teeter-totter cannot be used alone.

Another parent of a neurodivergent child (*PND12*) brought up the importance of having inclusive play dates involve activities where children have opportunities to succeed and to demonstrate their strengths: “*They can participate in activities where they excel and have a chance to demonstrate their knowledge or lead other kids. They can learn new skills with other kids.*” By arranging play activities that allow children to demonstrate their existing skills and learn new ones, parents are embedding supports within the play date.

In the design workshops with children, I witnessed children cooperating and collaborating by using embedded supports during the design activities. This was particularly salient as they built off each other's ideas. For example, in Workshop 2, when one child started making a "stuffie," other children started to do the same thing. Building also led to children working together. For instance, in Workshop 3, one child (CNT4) wanted to put tape around a group of straws, but he needed both hands to hold them together. Then, another child in the group (CND5) offered to put the tape around the straws while the first child (CNT4) held them together. This is an example of how even open-ended art activities give children opportunities to cooperate. There are formalized methods for embedding cooperation into art too, such as providing fewer supplies than are needed so children take turns and share (Sandall & Schwartz, 2002).

3.2.1.2 Transparency

Another theme that emerged from the data was how vital transparency among children and adults is to inclusive play, again mirroring Ochs et al.'s (2001) findings regarding the experience of elementary school students with autism in mainstream classrooms. For children, this means explaining the role of the environment, attitudes, and impairments in children's experiences of disability. For adults, this means explaining to the parent of the neurotypical child who the neurodivergent child is, what the child's needs are, and that both children have important roles in facilitating inclusive play.

A teacher interviewee (T2) noted that being open and honest with children has been an effective way to encourage social interactions between children with and without disabilities: *"One thing that I think has really helped with encouraging social interactions, especially for children who may have challenging behaviors ([e.g.,] tantrums, hitting, biting, etc.) that may make it harder for other kids to want to play with them, we tell the typically developing children honestly that 'Student 1 is still learning how to keep their body safe. We are all working on different things. You might be working on learning your letters... You can help remind them by telling them to have a safe body.'"* This example highlights how transparency can build empathy. By explaining to neurotypical children explicitly about their neurodivergent peers, they know what to expect and understand that

everyone has different things to work on. This has the potential to lead to more understanding and social interactions among children.

Survey and interview participants who were parents of neurodivergent children agreed that transparency is important among children and parents. One parent (PND16) mentioned in terms of being open with children, *“Kids often think my daughter is younger so rather than letting them treat her like a baby, I like to tell them about her strengths and also areas where she might be different. I think they are more likely to include her if they understand how she is different and also how she is the same.”* This parent felt that giving neurotypical children opportunities to better understand her daughter increases the likeliness that her peers will include her.

Regarding transparency with other adults, another parent (PND9) said, *“I think we can do so much to open up a dialogue between parents that can make everyone feel comfortable. I always tell parents that it is pretty much impossible to offend me so please, please, please ask me anything that they want to about [my child]. I guarantee I've heard every weird question that there is. I love making other people comfortable around him.”* Being open and transparent with other parents allows everyone to feel more comfortable and prepared for inclusive play.

3.2.1.3 Adjustability

As witnessed in the literature and during classroom observations, an important aspect of inclusive play is adjustability, meaning activities or objects must be adjustable to the needs of all children. This is in line with Universal Design for Learning (UDL), an educational framework for developing flexible environments that allow for equal access to learning, based on universal design (Rose, 1999). UDL maximizes opportunities for all children because there are multiple means of representation, action, expression, and engagement for activities, tools, and other relevant objects and experiences. By adjusting play experiences to meet the needs of all children through different means, all children are able to partake in them.

While parents of neurodivergent children did not mention adjustability as part of inclusive play, adjustability is a key component of the inclusive classroom, specifically because of how UDL is a part of

the Individuals with Disabilities Education Act, a federal law in the United States that ensures children are provided with appropriate services by their states and education agencies (“About IDEA,” n.d.). In the classroom, teachers were constantly modifying, individualizing, and adapting in the classroom, including play spaces, activities, and objects, to meet the needs of the students. Teachers customized each experience based on the children involved in order to include all of them. For play activities, this sometimes meant providing extra support with adult scaffolding. They also often incorporated child preferences into play activities, like involving two children’s favorite animated characters into pretend play to make it possible for both children to be invested. The adjustability of inclusive play activities and objects ensures more opportunities for successful play among the children because their experiences are individualized, customized, and motivated. These adjusted experiences take into account children’s abilities and needs (Sandall & Schwartz, 2002).

3.2.1.4 Focusing on Children’s Interests and Strengths

Within early childhood inclusive education, one type of curriculum modification is the use of child preferences in classroom activities (Sandall & Schwartz, 2002). Similarly, mutually reinforcing activities in play dates promote quality interactions and encourage the development of friendships between children with and without autism (Epstein, 2006). For inclusive play activities, I observed teachers making these experiences about the children as much as possible. When two children were paired as buddies for a play activity, the teachers announced the children’s commonalities (e.g., *both children love baseball!*), and the children were always excited. Although the children may be different in some ways, focusing on what the children had in common gave them something over which to bond and on which to focus their experiences.

One teacher (T5) explained the importance of giving the children options about preferred play activities to encourage social interactions during inclusive play. By offering choices to the children—like playing one buddy’s preferred game first and then after some time, switching to the other buddy’s preferred game—*“gives them that incentive to stay and play.”*

Parents commented on the value of focusing on shared interests among children and celebrating their strengths too. Some noted how children rely on common interests and preferred activities during inclusive play, as those shared experiences bring them together in the play date. In relation to what children should do during inclusive play, a parent of a neurotypical child (PNT24) said, *"I think anything that builds upon a child's strengths should be highlighted and encouraged."* While incorporating children's interests and strengths is important in play among solely neurotypical children as well, this is particularly important for children of differing abilities to find common ground and celebrate each other and themselves.

In line with stages of humor development (Cunningham, 2005), in the classroom and during the workshops, most children had similar senses of humor. This was true regardless of disability. Unexpected behaviors and actions, toilet humor, and other silliness made the children laugh. During the design workshops, all of the children thought making fart noises with balloons was hilarious, and they were hysterical when one child during Workshop 1 (CND1) kept turning off and on the lights in the room. Humor was common ground for the children.

3.2.1.5 Technology as a Tool for Inclusive Play

Teachers, parents, and children all used technology as a tool to facilitate inclusive play. Teachers used technology to support play and social interactions. They used individual iPad time as reinforcements for positive behaviors. Children also used technology in the classroom in innovative, collaborative ways for which the technology was not originally intended but were meaningful to them. For example, during free play in the classroom, one child dictated to another child what to type on the keyboard of a desktop computer; they switched off who typed and who dictated, so turn-taking was embedded in this activity. Children watched each other play games on the iPad during free choice too. To play a baking game, they passed the iPad around, so they could each add cookie ingredients. Again, turn-taking and sharing were embedded in this interaction.

When parents reflected on what was most important to them in terms of using technology for inclusive play, they commonly referred to the potential of technology to provide more opportunities for different aspects of inclusive play. They explained that they thought technology could provide children more ways to overcome communication barriers and more opportunities for parents to learn more about their children's friendships. Communication is often difficult for children in general, but in inclusive play situations, there may be more barriers to communication than in play with only neurotypical children. One parent (PND25) noted, *"Using technology will help those children find their voices and be able to really participate."* Another parent (PNT24) commented, *"Being able to reach out to another child who needs support or friendship via any mode of communication [like technology] can only be positive."*

Similarly, some parents viewed technology as a tool that would allow them to find out more about friendships and inclusive play moments. A parent of a neurodivergent child (PND19) believed parents should use technology to share great inclusive play moments. She said, *"I love seeing photos of my child playing with typically developing peers."* Likewise, another (PND28) said, *"I would be interested in learning more about friendships during the day at school [using technology]."* In these cases, parents believed technology could help them to discover more about their children's friendships, so they could feel at ease about their children and more easily set up play dates.

During an interview, one parent (PND33) said she would record her child during speech therapy and show the videos to her child's playmates. Using technology as a communication tool allowed her to be transparent and open with other children without the need for them to attend therapy sessions.

Some parents also noted how their children played video games during inclusive play dates. One parent (PND28) talked about how some Wii games her neurodivergent son and his friends play are collaborative: *"I know they were talking about how to hold the controller... So it's more of like how to help each other do better at it... 'Oh, if you step this way—here try this. No, let me try that.' Or they're laughing because you can create your characters on the Wii... They just make the most ridiculous characters possible, [like] Marty Fartcowski, the pitcher."*

This parent appreciated how her son and his neurotypical peers had social interactions in the non-digital world when using technology. The game also allowed them to find common ground in their silly senses of humor.

3.2.2 *Barriers to Inclusive Play*

Barriers to inclusive play identified in my study include tensions between what is required to facilitate play and what adults and children are actually able to do. Here, parallel to my description of how technology was helpful for inclusive play, I also report on perceptions of technology as an inappropriate tool to enable inclusive play. Later, I describe what implications these barriers have on the future design of technology in this space.

3.2.2.1 Effort required to facilitate inclusive play

In the early childhood education literature (Epstein, 2006) and as evidence in the data, creating a meaningful inclusive experience for young children requires a great amount of intentionality and effort by adults. In the classroom, providing high quality inclusion programs takes more than merely placing children of differing abilities in the same classroom. Among other things, it requires developing an appropriate curriculum that can be accessed by everyone, individualization, and adaptations (Cate, Diefendorf, McCullough, Peters, & Whaley, 2010). This requires teachers to know each student, his or her wants and needs, and the adjustments that are necessary to accommodate and attend to those wants and needs. Unfortunately, general education teachers often do not get enough support or do not feel prepared to teach children with special needs (Fuchs, 2010). This lack of support creates barriers to inclusion and, therefore, inclusive play in these settings.

Concerning home settings, parents reported on having to make great efforts to set up and monitor play dates among their neurodivergent and neurotypical children. Parents of neurodivergent children described the extremes they went to in order to support their children's friendships or support their children during play dates. Many of these efforts were directed at tackling the stigma and isolation experienced by children

with disabilities. For example, one parent (PND9) described how she tries to be open and available to other parents and let them know about how their children are friends with hers, so it is easier to set up play dates: *"I do a presentation at the beginning of the school year in [my child's] classroom. I send home a letter letting them know what we discussed with their kids that day and my contact info. I also attend the classroom get-togethers like parent night and try to remember which kids belong with which parents. Then I listen closely when [my child] talks about his friends from school so the next time I see their parents I can tell them that [my child] enjoys spending time with their child and what things they have done together that [my child] has told me about... I also ask his teachers to let me know if there are any great moments between [my child] and his classmates."*

Another parent of a neurodivergent child (PND16) described taking similar steps: *"When my daughter starts school every year, I send a letter to the school staff about my daughter and how she interacts with other kids. I also send a letter home to the parents so they know that there is a child with Down syndrome in their child's class. This allows them to discuss it with their child."*

However, parents also noted their busy schedules and hectic days. Not all parents have the time, energy, or resources to go to these great lengths. For instance, one parent (PND28) described an experience in which she was thankful when a family was honest about why they had not called to set up more play dates with her son. Although this parent said she was happy that finally another parent was honest with her and that the response was something she can *"work with,"* the incident manifests the barrier to inclusive play: *"... one parent said, 'I find when you ask for a play date with [your son] that I have to really make sure that I'm prepared for it.' I'm like, 'Oh, what do you mean?' She's like, 'He has so much energy and he just needs to be busy.' She said, 'I just need to be in the right frame of mind to take him on.' She said, 'I love when I have him here. But if I'm having a tired day, that's not going to happen.'" The fact that the parent of the neurotypical peer had to change her frame of mind for this participant's son to come over acted as a barrier to them playing together.*

3.2.2.2 Children's Preferences

While we described how focusing on children's interests and strengths can help teachers or parents facilitate interactions between children, children's preferences can also interfere with inclusive play when they are not given the support they need. We observed that children who are not offered appropriate support end up playing in parallel when they are developmentally ready to engage in collaborative play. This is a missed opportunity for developing crucial social and emotional skills through play. Similarly, a parent of a neurodivergent child (PND2) noted how sometimes it looks like her son is playing with other children but really is not interacting with them: *"Overall it seems like he plays in a big group of children. But when observed over a period of time, you will see that there is no actual interaction between him and his peers. He looks at other children sometimes but wouldn't want to join in.... Although other children try to interact with him, he tends to ignore or refuse them."*

During design workshop sessions, children sometimes preferred to play alone. When one neurodivergent child in Workshop 1 (CND4) was making an alien by himself and one neurotypical child (CNT5) was making something else by himself, we suggested they combine projects. The first child (CND4) was insistent that his alien head did not need a body and that he would not join his project with the other child's (CNT5).

Other parents of both neurotypical and neurodivergent children commented on how they believe that children's perceptions of playmates can be barriers to inclusive play because they are drawn to kids who are similar to them and stay away from those who seem different, which is similar to the conclusions of Ochs et al. (2001). Some parents explained how a lack of understanding of differences might be more at the root of a child's preference to not play with other children. One parent (PND16) said, *"Generally, I believe kids want to play with other kids. If they try one thing to engage another child and it doesn't work, they will usually try something else. I think they look for parents, though, if they can't understand the differences in another child. If it is too hard to understand, they will likely go play with someone else."*

Additionally, during the workshops, although some of the most meaningful experiences occurred when the children built together, this often occurred when each child had a clear stake in the end goal, which brought attention to him or her as an individual. For instance, when one child (CNT2) was building a spaceship for aliens, another child (CND1) added a rope onto the spaceship for *his* alien. Moreover, when a child (CND5) was building a robot and another child (CNT4) helped, the first child (CND5) always referred to the robot as *hers* and never *theirs*. It was important to most of the children to be able to bring their creations home too. In these instances, the children were working together but not pushing past their own individual preferences. While being egocentric is developmentally appropriate from age 2 to 7 (Piaget, 1971), this can be a challenge for children to engage in inclusive play.

3.2.2.3 Unfamiliar territory for parents

Some parents of neurodivergent children had negative views of other parents, commenting on how they believed other parents of neurotypical kids were the biggest barriers to inclusive play. A common perception was that parents of neurotypical children were uninformed about disabilities and the needs of children with disabilities. One parent (PND9) stated parents' "*fear of the unknown*" is a barrier, while another (PND6) was blunter: "*[The biggest barrier is] parents who don't value it. They aren't willing to push past their own personal discomfort/misunderstanding/preconceived notions about a particular diagnosis to allow their children to have new experiences. They may assume that there are medical or behavior issues that don't exist and therefore don't include my daughter in play dates or party invitations.*"

However, all 23 parents of neurotypical children I surveyed reported advantages of having their children play with neurodivergent children, such as learning acceptance and an appreciation of human diversity, which is a main goal of inclusion (Sandall & Schwartz, 2002). Eighteen of the 23 parents of neurotypical children answered that they *would* be interested in having their child play with more neurodivergent children if given the opportunity. Unfortunately, 15 of these 18 parents reported that their children have not previously had any opportunities to play with neurodivergent children. They described a lack of neurodivergent acquaintances, with no such children in their child's classes, at their school, or in their

neighborhood. Addressing the perceived lack of opportunity to engage with neurodivergent children is an important design opportunity in the inclusive play design space.

Finally, there were a couple reasons the remaining five parents were not interested in having their children play with more neurodivergent children if given the opportunity: either they let their children choose their own playmates or their children already have some experience playing with neurodivergent children. One of these parents (*PNT34*), who said her children play with children with autism and ADHD, was not interested in having her child play with more neurodivergent children because it is unfamiliar territory. She was the only survey participant to explicitly mention a lack of understanding of disabilities: *"I don't have full knowledge...I wouldn't know how to react or interfere if need be."*

When parents of neurotypical children described possible disadvantages of inclusive play, some disclosed how they were concerned their children might not understand the other children and this might cause frustration, anxiety, confusion, or fear. The majority indicated that they believed there were no disadvantages, which may have been due to response bias (i.e., parent participants may have not wanted to suggest, in the context of this study, that they did not support inclusion nor children with disabilities). Only one parent of a neurotypical child (*PNT48*) harbored a negative view that playing with neurodivergent children might *"diminish [her daughter's] desire to learn as much as she can"* and so *"she may regress in terms of her learning."* These fears reflect ableist beliefs and misperceptions that can be significant barriers to inclusive play and to people with disabilities in general.

3.2.2.4 Concerns about Technology for Inclusive Play

Teachers' and parents' opinions about technology lowered their willingness to adopt technology for inclusive play, as they perceived technology engagement as an independent and/or passive activity for children. Although all teacher participants used the iPad as a reinforcement tool in their classrooms, two teachers mentioned issues they had with the technology for their students. One teacher (*T1*) said, *"I like how much [the iPad] motivates the children to help them be their best [selves]. I don't like that its main emphasis is on*

solitary play and not on social interactions or cooperative play." This statement is consistent with my observations of some children playing with the iPad or on the computer in the classroom purely independently.

The majority of parents of neurodivergent children reported that they did not use technology during inclusive play. Many noted that they did not find technology to be interactive between children. One parent (PND21) said she believed that instead of using technology, *"children should be doing activities that give [them] an opportunity to socialize together."* As opposed to seeing technology as a tool that could embed supports for interactions, parents did not believe technology could help children practice their play or social skills and thought that children might become too reliant on technology as a tool.

Some parents of neurodivergent children also had issues with technology as a "crutch" that does not enable, augment, or scaffold interactions in the real world. For example, a parent (PND28) said using technology during play dates was not always a good idea for her son because it is *"a little too easy to stay in your own head,"* and *"he [needs] to step out of his head and get out there and have a direct interaction."* Another parent (PNT26) corroborated this view, as she believed that technology did not support true interactions: *"Other than breaking the ice, I feel like it prevents the kids from really playing together... They're interacting with the technology. They might be collocated but they're not actually interacting with each other."*

3.3 DISCUSSION

Based on the results of this study (see Table 3-2 for a summary), there are a number of considerations one can take to design technology to support children with inclusive play. The facilitators and barriers to inclusive play present opportunities for children, teachers, and parents to use technology to make meaning in their individual and joined experiences. In the discussion, I consider how technology may help facilitate and overcome barriers to inclusive play by providing current technology examples. Lastly, I ground my discussion in a scenario with a fictitious technology example that accounts for all of the facilitators and

barriers – this technology example served as a basis for brainstorming, designing, and building a prototype for inclusive play, which I detail in the next chapter (Chapter 4).

Table 3-2. Summary of inclusive play facilitators and barriers.

Type	Description	Example
Facilitators	Direct support	“It bugs me when... I wish you would...” language
	Embedded support	Sharing art supplies
	Transparency	Explaining how all children are similar and different in various ways
	Adjustability	Adults scaffold each child’s play interactions as needed
	Focus on child interests & strengths	Toilet humor is funny for children, regardless of disability
	Technology as tool	Children take turns on keyboard
Barriers	Effort required	Planning, intentionality, and attention needed for inclusive play
	Children’s preferences	Children misunderstand differences in others and avoid these people
	Unfamiliar territory for parents	Parents do not have experience with children with disabilities
	Technology concerns	Technology can be solitary

3.3.1 Design Considerations

The facilitators and barriers I identified can be used to examine the gaps and affordances of current technologies to maximize children’s opportunities with inclusive play. For example, more games like SIDES (Piper et al., 2006) could be designed to decrease the *effort required to facilitate inclusive play* by enforcing rules within gameplay to encourage cooperation *implicitly*. Sesame Street programming and interactive media (Gikow, 2009), which incorporate characters with disabilities (*implicit teaching*) and teach about disabilities *explicitly*, can inspire technology designs that promote *transparency*, open communication, and reflections on biases. Other technologies like the Augmented Knights Castle, which incorporates children’s voices into the toy (Farr, Yuill, Harris, et al., 2010), offer examples of how to make play in this context *adjustable*. Adjustable technologies also offer new ways for children to experience *shared interests* and show each other their *strengths* based on how and what they create with the tool. Likewise, more technology features like the “shared interest gear” of the Mobile Social Compass (Tentori & Hayes, 2010), which allows children with autism to find potential communication and play partners with similar interests, could be incorporated into technologies for inclusive play. By using the conceptual framework of

inclusive play developed in this paper, designers can identify affordances of current technologies that can be replicated and generalized to future technologies to maximize opportunities for inclusive play.

The facilitators and barriers I identified can also be used to understand what *not* to design. For example, the areas in which adults are *concerned about technology* for children suggest that technologies should be designed to scaffold children's interactions, rather than act as a crutch that inhibits interpersonal growth. A positive example of this type of scaffolding is CamQuest (Berggren & Hedler, 2014), a simple pedagogical tool that enables preschool children to recognize and explore geometric shapes by taking pictures of objects in their environment. There is no automatic recognition or feedback from the system, which enables children and adults to discuss why the objects in the pictures fit or do not fit in the shape, fostering real-world interactions and discussion.

3.3.2 *Example Technology Scenario*

To better contextualize the findings as they apply to design, I imagine an interactive technology that incorporates all of the facilitators, overcomes barriers, and takes other technology considerations into account. It is important to note that this is merely one design direction; the insights from this study may effectively translate into, for instance, the design of an after-school program or a non-technological based artifact. However, here, I describe a simplified scenario in which parents and children use an imagined technology based on my findings.

Consider Alex, parent of five-year-old Morgan who is neurodivergent. Alex wants to help Morgan develop social and emotional skills and strengthen friendships. Jordan is a neurotypical child in Morgan's kindergarten class. Jordan's parent is Taylor. Parents Alex and Taylor meet when picking up their children from school and plan a play date for their children.

During the play date, Morgan and Jordan play an interactive adventure game on the iPad that augments interactions with the natural environment. To help them make their way through the adventure game, the iPad prompts the children to ask each other questions (e.g., *"To unlock the door, ask your adventure partner*

what his or her favorite food is and draw a picture of it together on the screen"). In other instances, the iPad prompts the children to take pictures or videos of each other (e.g., *"Take a picture together where you are both making your silliest faces."* *"Record each other making your loudest fart noises,"* or more seriously, *"Record your partner telling you what you should do to make him or her feel better when he or she is sad."*). By completing the tasks outside of the digital environment, almost like a recordable activity book, the children complete the game together. Parents Alex and Taylor can both review the game remotely to look at the pictures, videos, and other logs of the children's game progress.

This interactive technology offers Morgan and Jordan *direct support* by prompting interactions that relate to social and emotional learning or by explicitly teaching these topics. It provides *implicit support* by embedding turn-taking and cooperation within the game setting. There is a focus on *transparency* for both of the children and their parents. Through direct supports, Morgan and Jordan can learn that all children are similar and different, and they learn about their own similarities and differences. With the option to review their children's play, the parents can learn more about the friendship and how to support their child's friend. This remote viewing can help facilitate conversation beyond the technology for the parents as well. The game is *adjustable* because Morgan and Jordan choose what to record based on their own preferences and abilities. It also highlights the children's *strengths and interests* because gameplay with Morgan and Jordan is different than it would be with other pairs of children. They have the chance to customize their play to fit their wants and needs because the content of the recordings or drawings are based on the specific children's gameplay.

This technology would ideally lower the *efforts required* to set up and monitor inclusive play dates due to how parents Alex and Taylor can use the game to better understand their children and communicate within and beyond the technology. This would also help educate Taylor to address any *inexperience* Taylor has with children like Morgan. Because Morgan and Jordan get to record themselves, talk about themselves, and show each other their strengths, any *preferences toward individuality* in play could be preserved without

getting in the way of them playing together. A focus on interactivity beyond the digital environment addresses *concerns with technology* regarding solitary play with technology.

Play with this interactive technology is semi-structured, as it involves a more structured game that can be completed through more imaginative, unstructured tasks. The game is also intended to be fully inclusive for children with diverse abilities and needs. Overall, this scenario is an example of how future interactive technology design might utilize and build on this work.

3.4 SUMMARY OF CONTRIBUTIONS

In this chapter, I argue for ways in which interactive technology can be designed to provide empowering, supportive opportunities for adults and children to engage in inclusive play. Specifically, I examined inclusive education as an archetype for high quality inclusive practices, worked with and observed children, and elicited adults' opinions on inclusive play and technology. From this, I generated a thematic description of the current state of inclusive play, highlighting key facilitators and barriers of inclusive play, which the Human-Computer Interaction, Child-Computer Interaction, and Interaction Design & Children communities can use to shift their perspectives on how to design for and with neurodivergent children and their neurotypical peers. Through my discussion, I argue interactive technologies should be designed to harness the facilitators and help overcome the barriers in order to increase children's opportunities to engage in inclusive play. This study contributes an empirically-based generative understanding of the current state of inclusive play that can inform technology design in this area.

Chapter 4. INCLOODLE 1.0: DESIGNING & EVALUATING AN INTERACTIVE APP FOR NEURODIVERSE CHILDREN²

Based on the formative work I described in Chapter 3, I designed and developed four slightly different versions of *Includle 1.0*, a picture-taking iPad application prototype, designed for pairs of children with diverse abilities and needs to play with together, inclusively. I used this application as the basis for a within-subjects mixed-methods laboratory study that allowed me to investigate RQ3—*how specific technology design features may support neurodivergent and neurotypical children with inclusive play directly on a single device*—in a controlled setting. More specifically, in this investigation, I asked two main sub-questions about certain design features: (RQ3-1) *Does technology-enforced cooperation lead to more successful inclusive play compared to no technology-enforced cooperation?* and (RQ3-2) *Does character-based prompting within an interactive technology lead to more successful inclusive play than basic prompting techniques?*

Guided by the related work in this space (Chapter 2.7.1), I hypothesized that technology-enforced cooperation would be more supportive of inclusive play compared to no technology enforcement (H1). I postulated that the notion that technology can successfully provide structure to scaffold play and social interactions for homogenous groups may likely generalize to children with more heterogeneous needs. Again, informed by the success and positive impact of characters in technologies and new media (Chapter 2.8), I hypothesized that character-based prompting would be more supportive of inclusive play than simple content (H2).

² Sobel, K., Rector, K., Evans, S., & Kientz, J. A. (2016, May). Includle: Evaluating an interactive application for young children with mixed abilities. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (pp. 165-176). ACM.

By designing my own inclusive play application and using it as the basis for a lab study, I also continued to inform my answer to how we might intentionally design technologies to support neurodiverse children in playing together.

In what follows, I describe the design of Incloodle 1.0 and the four prototype variations. I then detail the lab study methods, report on the results, and discuss what these results mean in the context of designing inclusive play technologies.

4.1 INCLOODLE 1.0 DESIGN

Based on the results of the foundational study (Chapter 3) and an iterative, collaborative design process, I, along with the consistent help of two collaborators, designed and developed the first prototype of an interactive application for children with diverse abilities to use together: *Incloodle 1.0*. Incloodle is a photography-based iPad application for two children to play together on a single device. The goal of this application is to facilitate and lower barriers to inclusive play.

I programmed the app prototype in Swift 1.2 within Xcode 6.4. I implemented real-time face recognition in Incloodle using Apple's AV Foundation Framework, which interprets face metadata captured from video input. The application operated on an iPad Air 1, running iOS 8.3.

Foremost, I was driven to design an interactive application because of how it can provide structure via predictability, rules, and stability, especially for children with autism (Frauenberger, 2015b). I chose to design for a touchscreen tablet specifically because of its popularity, portability, accessibility, and usability among children (Brooks, 2012; Fidgeon, 2011) and because of its camera feature. I focused on using the camera for picture-taking because photography is in line with constructionist approach to learning (Papert, 1980), as children construct a shared picture together. Photography also specifically provides triggers for conversation, contextualizes experiences, and can empower users (Byrnes & Wasik, 2009; Carter et al., 2014). Photography is also a learning tool for young children in social and emotional development (Byrnes

& Wasik, 2009). Photographing their own faces encourages children to focus on faces and emotions in relation to themselves and to others, which is important for developing theory of mind, perspective taking skills, and empathy (Byrnes & Wasik, 2009). These social and emotional skills can support both neurotypical children and neurodivergent children in understanding each other.

In line with this idea, I designed Includle to concentrate on social and emotional learning. Includle introduces different social and emotional learning topics through character anecdotes, questions about the children, and prompts for the children to take pictures together that correspond to each topic. The topics include happiness, sadness, anger, embarrassment, cheering up others, frustration, grumpiness, calming down, discomfort, being scared, silliness, worry, what you are working on, favorite shapes, favorite colors, and favorite toys. I developed and curated the topics and the wording of the written and spoken questions and prompts based on my formative work about inclusive play (Chapter 3) and on children’s literature that focuses on social and emotional learning and teaching about disability (Beech, 2012). After generating a first draft of this content, Ashley Green, an early childhood education teacher, reviewed and edited the content. She and I engaged in a discussion about each topic and edited the final content together. (Please see Appendix A, Appendix Table 1 for a full list of Includle 1.0’s content.)

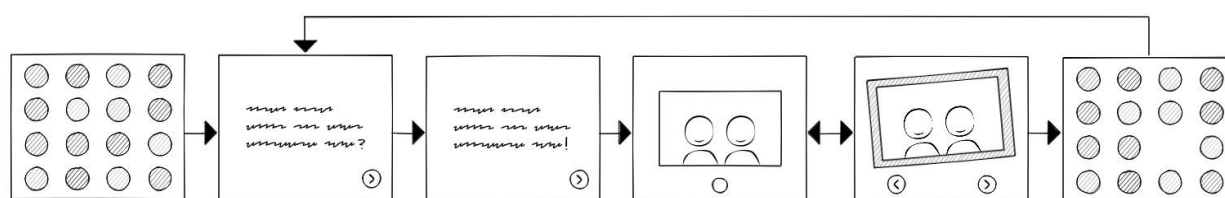


Figure 4-1. Wireframes and interaction flow of Includle 1.0.

Includle 1.0’s basic wireframes and interaction flow are shown in Figure 4-1. Includle gives the child players a matrix of “objects” from which to choose; this “object” directly relates to a subsequent discussion point or question about a social-emotional learning topic. Next, the application prompts the children to take a picture together with a specific kind of physical object or making a specific face, either of which relates to the social-emotional learning topic. After they take the photograph, Includle then shows the

children their picture, and they return back to the “object” matrix (where the prior “object” they had chosen has been removed). Audio accompanies all text in the app to remove the need for reading literacy. Additionally, the audio prompts repeat if there is no app activity for 30 seconds. Buttons wiggle if they are not tapped to provide clues about interaction capabilities.

4.1.1 *Addressing the Design Considerations*

The Includle design is intended to harness the facilitators and overcome the barriers to inclusive play (Table 3-2). Includle may *facilitate* inclusive play by providing direct support for play interactions, increasing transparency, and focusing on child interests and strengths by explicitly referencing personal social and emotional content. The application asks the children to talk about their wants, needs, and interests while taking pictures of themselves. This feature allows the children to demonstrate their understanding of different emotions and also share a silly, face-making experience. The open-endedness of the questions and prompts allows it to be adjusted to any pair that plays with the application. Includle also provides embedded support (i.e., ways for children to learn through experience as opposed to being taught concepts explicitly) for turn-taking and cooperation in gameplay and in picture-taking.

Includle may *lower barriers* to inclusive play by enabling playmates and their caregivers to learn about the children’s wants and needs through the questions and prompts. For example, by hearing the children discuss what they might want when they are upset (as prompted by Includle), caregivers may better know how to support a child in times of need, away from the application. This allows the children and adults to be more familiar with each other. When the children learn about each other’s similarities and differences during gameplay, it provides an opportunity for them to increase positive attitudes about each other and for people who are different than themselves. Finally, Includle is not an application for a single user. Instead, it is cooperative and social. The questions can generate discussion; the picture-taking is a shared experience, and the ability to immediately view the pictures taken allows for discussion and reflection.

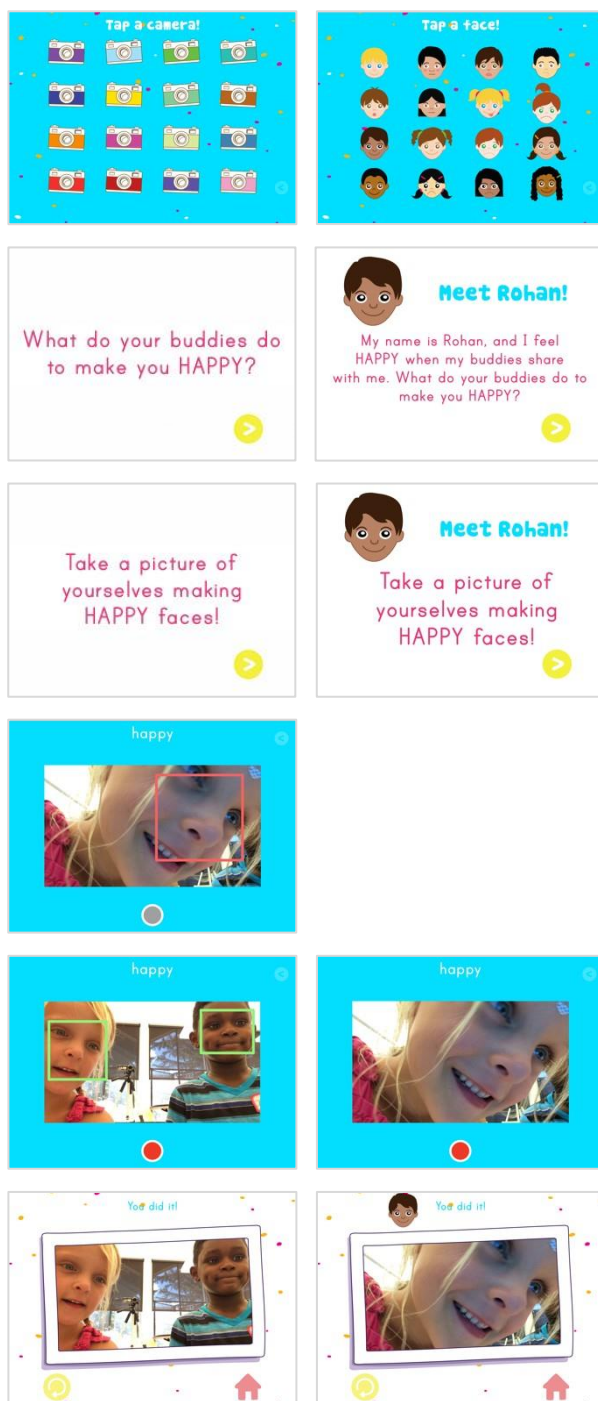
4.1.2 Four Versions of Incloudle 1.0

The first working prototype of Incloudle served as the basis for a laboratory study to evaluate specific design features ability to support children with inclusive play (i.e., answer RQ3: RQ3-1, RQ3-2). Therefore, while the basic structure of the application remained the same, there were four different versions of Incloudle 1.0 (Table 4-1). These versions varied in (1) whether or not it technologically-enforced cooperation, where ‘cooperation’ is narrowly defined as both children’s faces being “in” the picture (verified through the face detection software) and (2) whether or not the app included characters or basic prompts (i.e., character-based prompting or basic prompting) as the drivers of interactions within the experience. Figure 4-2 shows the interaction flow of two of the four versions of Incloudle 1.0.

Table 4-1. Versions of Incloudle 1.0. Each version corresponds to a condition within the within-subjects lab study.

	No technology-enforced cooperation	Technology-enforced cooperation
Basic prompting	Version 1	Version 2
Character-based prompting	Version 3	Version 4

As described, when engaging with Incloudle, children are prompted to take a picture together by making certain faces or with a particular object. In the version with *technology-enforced cooperation*, the application performs face recognition. When zero or one face is recognized, the camera shutter button is disabled. When one face is recognized, a red box is shown around the face. If a child taps the disabled shutter button, the application says, “Make sure both buddies are in the picture.” When two faces are recognized, there are green boxes around each face and the shutter button is enabled. When there is *no technology-enforced cooperation*, the shutter button is always enabled, and there are no boxes around the players’ faces.



Start screen: The children choose a topic from the start screen via a picture of a camera or a character's face, which are randomly ordered in a matrix in each launch. The application says, "Tap a camera," or "Tap a face."

Topic introduction & question prompt: The children are introduced to a topic about themselves or about social and emotional learning. They are asked a question about this topic.

Picture prompt: The children are prompted to take a picture that relates to the topic introduced previously. This involves making certain faces in the picture or taking a picture with specific objects.

Picture-taking/disabled shutter button: The children take a picture together using the iPad's front-facing camera. Here the shutter button is disabled because both children's faces are not recognized by the application.

Picture-taking/Enabled shutter button: The children take a picture together. Here the shutter button is enabled; on the left, this is because both faces are recognized by the application. On the right, there is no enforcement, so the shutter button is always enabled.

Review of picture: The application says, "You did it!" and shows the picture taken. Children can then choose to retake the picture or go back to the start screen. The completed topic no longer appears on the start screen.

Figure 4-2. Includle system screenshots. *Left column:* Version 2: technology-enforced cooperation + basic prompting. *Right column:* Version 3: no technology-enforced cooperation + character-based prompting. Artwork created and edited by Lucas Colusso. Original character images created by ©Liz

Aragon.

How the content is presented to the children depends on whether or not there is character-based prompting. During the *basic prompting condition*, the children choose from a matrix of cameras, and the topics are presented through text and audio with an adult female voice. With *character-based prompting*, the children choose from a matrix of character faces. They meet a character who tells the children an anecdote about herself or himself that relates to the picture-taking prompt via text and audio. All of the audio is spoken in the voice of the character.

4.1 METHODS

I carried out a mixed-methods 2x2 within-subjects short-term laboratory study. The four conditions varied in whether there was technology-enforced cooperation (i.e., requiring that both children's faces must be in the picture) and in the type of prompting the app provided (basic vs. character-based) (Table 4-1). I used a 4x4 Latin Square design to counterbalance the order of the conditions for the eight study sessions. I randomly assigned each condition order to two study sessions. However, due to recruitment limitations and cancellations (covered in the section below), I did not have a perfectly balanced Latin Square.

4.1.1 Participants

I recruited a total of 20 unacquainted children, 10 of whom were neurodivergent and 10 of whom were neurotypical, using the University of Washington Communication Studies Participant Pool, which is a list of people in the community interested in participating in research studies. The inclusion/exclusion criteria were verbal children between the ages of 4.5 and 7 years who were either neurodivergent or neurotypical, as reported by their parents. I also recruited one parent per child. For the study, I attempted to pair one neurodivergent child and one neurotypical child by closest age/rising grade, by gender, and by study time availability. However, scheduling constraints of the participants restricted my ability to match all dyads by age/rising grade and gender.

Children were not only diverse within a pair, but they were also diverse across pairs; not all neurotypical children were or are the same and not all neurodivergent children were or are the same. Being neurotypical

does not necessarily imply that a child does not have his or her own social or emotional skills to work on. A child being diagnosed with a disability or disorder does not imply he or she has to work on social or emotional skills. Due to one cancellation and one mismatch where both children were neurodivergent, there were a total of 16 child participants (9 male, 7 female; mean age = 6 years, 1 month; SD = 9.4 months) and 16 parent participants (all female). See Table 4-2 for the final information for the child pairings. All children had prior experience using touchscreen tablet or iPad applications. I compensated adult participants by giving them a US\$25 Amazon gift card. I also gave the children the option to choose up to two small toys, worth about a US\$1, from a toy bin. While not required for their children to participate in the study, all parents gave permission for the pictures and recordings of their children to be shared for research/educational purposes.

Table 4-2. Participant pair information. *Rising grade indicates at what grade the child starts school in the following year.

Pair	Diagnosis	Gender	Age	Rising grade*
1	Sensory perception disorder	Male	5y0m	K
	Neurotypical	Male	4y11m	K
2	High-functioning autism	Male	6y8m	1
	Neurotypical	Male	7y0m	1
3	High-functioning autism	Female	7y4m	2
	Neurotypical	Female	6y10m	2
4	Anxiety	Female	7y5m	2
	Neurotypical	Female	6y3m	1
5	Developmental disability	Male	6y1m	1
	Neurotypical	Female	6y0m	K
6	Anxiety	Male	6y0m	1
	Neurotypical	Female	5y8m	K
7	Sensory perception disorder	Male	5y5m	K
	Neurotypical	Female	5y6m	K
8	Developmental disability	Male	5y4m	K
	Neurotypical	Male	6y0m	1

4.1.2 *Setting*

The children played in the middle of a design studio-based classroom at the University of Washington. They sat at a small table (Figure 4-3) while the parents sat and watched from the side of the room. I sat in

a chair next to the small table, and another researcher sat closer to the parents (or vice versa). There were tables set up in the corners of the room for between-condition child questions, and snacks and water were at the front of the room for whenever the participants needed them. Children used one iPad to play Incloodle and used a different iPad to take standard pictures before and after playing with Incloodle. Both iPads had large foam child-friendly cases with handles, and when in use, the iPad rested against a stand on the table (Figure 4-3). I video recorded the sessions with two cameras, in front and behind the children, and audiotaped the child interviews.



Figure 4-3. Lab study setup.

4.1.3 Procedure

The study took approximately one hour per session. Another researcher and I facilitated the session. One researcher briefed and debriefed the parents while the other ran the study with the children. Both of us asked the children questions following each condition.

At the beginning of the session, the children went to the center of the room to meet each other and play with blocks for five minutes while their parents signed consent forms and were briefed on the study. After the children played with the blocks, the researcher explained to them what they would be doing. The children practiced using the iPad's front-facing camera to ensure that they understood how to take pictures. Before each condition, the researcher explained to the children that they needed to listen to the directions

and take pictures together, and that their faces either did or did not have to be in the picture. While their parents observed, the children played with the iPad in a condition for between three and eight minutes. A prior power analysis revealed each session could be three minutes minimum, which was ideal for the young participants. However, some children asked to play longer. After each condition, the other researcher and I asked the children a few questions, and they received a sticker. The parents also filled out short questionnaires about the play condition during this time. After all of the conditions were completed, the children were allowed to play with the iPad camera however they liked for five minutes.

4.1.4 *Parent and Child Questions*

On paper-based questionnaires, parents answered 5-point Likert-scale questions with optional explanations regarding their children's happiness and comfort and how pleased they were with their children's experiences during each condition. Because the majority of parents' qualitative answers only discussed how their children felt being with new people in a new environment, instead of their children's experiences playing a particular version of the application with their playmate like I intended, I do not include the quantitative responses in the results or discussion.

The children also answered a series of quantitative and qualitative questions about how much they enjoyed the game (Read & MacFarlane, 2006), how easy they thought the game was to play, if they would like to play the game at home/school, and how close they felt to their playmate (Rabinowitch & Knafo-Noam, 2015). However, there was significant acquiescence bias from the children, as they generally misunderstood the meaning of closeness in a relationship (i.e., believed it meant physical distance). Therefore, I only examined the limited qualitative responses from children.

4.1.5 *Adapted Definition of Successful Inclusive Play*

For this research, I created a definition of successful inclusive play with Incloodle by adapting Cross et al.'s (2004) definition of successful inclusion in the early childhood classroom to my short-term lab investigation. Cross et al. (2004) define "successful inclusion" as occurring when (1) children make progress

on their individual goals; (2) children make progress in their personal development and in knowledge acquisition expected for all children; (3) children are welcomed and accepted as full members of the group; and (4) children's parents or caregivers are satisfied with their children's gains and how happy and comfortable their children are in the group.

In my adapted definition, inclusive play is successful when: (1) the technology supports the children in the development of play skills anticipated for all children; (2) the technology fosters acceptance and positive attitudes between children; and (3) parents appear pleased with their children's play experience and participation and report their children appeared comfortable and happy in the play setting.

4.1.6 *Quantitative Coding and Analysis*

Related to my adapted definition of inclusive play success, the two main quantitative dependent variables were child *affect* and *synchronous reciprocal interactions*. Koegel et al. (2005) developed these measures for their study on play date interactions between children with autism and typically developing peers. *Affect* assesses children's comfort and happiness on a 6-point Likert scale (0-1 being negative, 2-3 being neutral, and 4-5 being positive). *Synchronous reciprocal interactions* address positive attitudes between children and development of play skills. These interactions occur when both children engage in social communicative behaviors (verbal initiations and responses, eye contact, facial expressions, and/or gestures) at the same time. Successfully taking a picture together did not count as a synchronous reciprocal interaction. I divided the video recordings of each condition into 30 second intervals. Then, two coders rated the affect of each child during each interval. If a child pair was engaged in synchronous reciprocal interactions for the majority of the 30 seconds, the coder also marked the interval as "yes" (1) for synchronous reciprocal interactions; otherwise, the coder marked the interval as "no" (0).

The two coders independently coded 20% of the recorded data. For affect, Cohen's κ was 0.819. For synchronous reciprocal interactions, Cohen's κ was 0.890. Afterward, they discussed their disagreements,

adjusted their mismatched codes, and then coded the remaining data separately, which was split evenly between them.

I ran a Repeated-Measures ANCOVA with neurodiversity (specified as yes/no) as a covariate to analyze the main effects of tech-enforcement and prompting on child affect. Because I used a Latin Square design, I could not analyze the interaction effect. Next, since the synchronous reciprocal interactions measure is categorical (yes/no), I could not analyze these results using a general linear model. However, compressing the data into a frequency (the percentage of time synchronous reciprocal interactions occurred in each condition) leads to eight data points per condition (i.e., one frequency per pair), which I analyzed using an ANOVA. Again, I could not analyze the interaction effect due to the Latin Square design.

4.1.7 *Qualitative Coding and Analysis*

I also aimed to understand qualitative differences in play based on the varying conditions and/or themes regarding play based on other static design features. Another researcher and I content logged all of the videos, adding observational and analytical annotations throughout the process and transcribing key illustrative interaction sequences (Derry et al., 2010). We then took a grounded approach to analysis by performing open coding on the data, iterating on loose codes with more specific codes as we iterated through the data (Corbin & Strauss, 2008). Throughout this analytical process, we focused on the impact of particular design features of Incloodle on the children and their interactions with each other and with the application, including, for instance, body language, joint attention, eye contact, pointing, gestures, prompted and unprompted utterances, turn taking, mimicry, control, focus, and engagement.

4.2 RESULTS

4.2.1 *Effects of Tech-Enforcement on Inclusive Play*

Technologically enforcing joint picture-taking changed play between the children in meaningful ways. There was a significant main effect of enforcement type on affect, $F(3, 12) = 5.85, p = 0.012, \eta^2 = 0.84, 1 - \beta =$

0.91, such that the children had more positive affect when there was no technology-enforcement ($M = 3.01$; $SD = 1.06$) compared to when there was technology-enforcement ($M = 2.76$; $SD = 1.04$) (Figure 4-4). There was not a significant main effect of enforcement type on the frequency of synchronous reciprocal interactions between conditions, $F(3, 4) = 0.047$, $p = 0.83$, $\eta^2 = 0.007$, $1 - \beta = 0.054$. There were not major differences in the percentage of time with synchronous reciprocal interactions between the tech-enforcement ($M = 32.6\%$; $SD = 27.1\%$) and no tech-enforcement conditions ($M = 31.2\%$; $SD = 27.1\%$), but (as seen in the large standard deviations) there was extremely high variation among the dyads in both cases. Figure 4-5 shows the average percentage of 30-second intervals with synchronous reciprocal interactions.

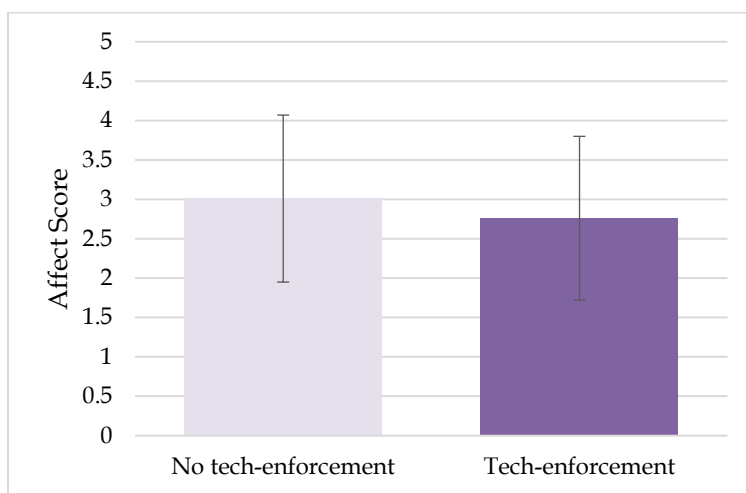


Figure 4-4. Average affect scores across participants over time, comparing conditions with and without technology-enforced cooperation (0-1: negative, 2-3: neutral, and 4-5: positive). Error bars represent \pm one standard deviation.

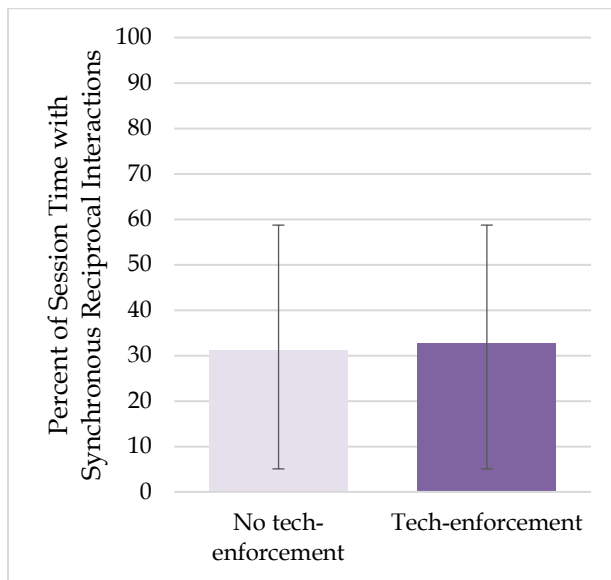


Figure 4-5. Average percent of session time with synchronous reciprocal interactions across dyads, comparing conditions with and without technology-enforced cooperation. Higher value indicates more synchronous reciprocal interactions during play. Error bars represent \pm one standard deviation.

By design, technology-enforcement via face recognition ensured both children's faces were in the picture, so most cooperated with picture-taking in this condition. However, being coerced to take the picture together when they may not have wanted to, either because they would have rather played separately or because they would have rather explored taking pictures of other things, may have led to these differences in affect.

The fact that some pairs needed enforcement to cooperate became most evident when they were using Includle without enforcement. In these cases, the children used the iPad totally separately when there was no tech-enforced cooperation. Either each child took turns holding the iPad to himself or herself, or one child dominated picture-taking until the other child disengaged. For Pair 1, each child held the iPad in his lap at different times and played completely separately. When the neurodivergent child in this pair did not get a turn, he asked the researcher for help. In Pair 5, the neurotypical child dominated picture-taking by only including her own face in the pictures until the neurodivergent child asked the researcher for help as well. In these cases, the resulting pictures only included one of the two playmates (see Figure 4-6).

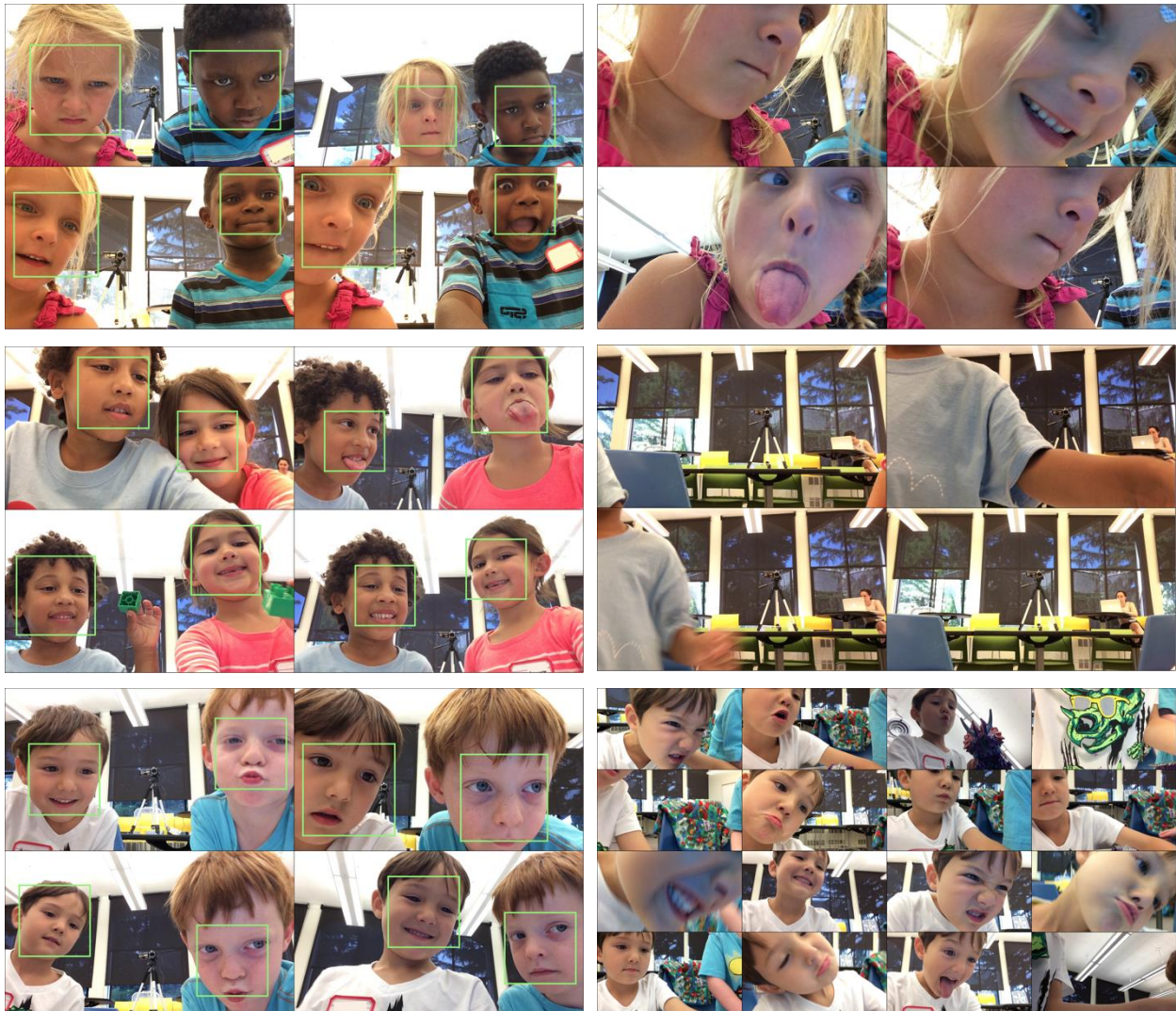


Figure 4-6. Pictures taken by pairs of children when cooperation was technologically enforced (left column) and when cooperation was not technologically enforced (right column).

Not having tech-enforcement caused a significant problem in Pair 3 when the neurotypical child took a picture of herself with a block while her neurodivergent playmate was still searching for one. After being left out, the child cried and hid under a table. Although the researchers and parents intervened and restored the game to allow the girls to retake the same picture together, it was not enough to improve this child's experience. She explained later she hated this version of Includle because she "*missed the picture.*" Thus, tech-enforcement largely helped pairs who had trouble cooperating and being patient with each other. For

instance, when Incloudle had tech-enforcement, rather than leaving her playmate out, the neurotypical child of Pair 3 helped the neurodivergent child move her face into the frame so that it could be recognized.

However, there were some instances in which tech-enforcement hindered the children's experiences, especially for the pairs who did not need face recognition to ensure cooperation. For these pairs, enforcement limited their exploration. I did not initially expect children would have so much fun purposefully not following the prompts of the application, but it later became clear how silly and fun it was to break the rules by disregarding the prompts. Without face recognition, some children realized they could take pictures without their bodies or faces. Pair 2 negotiated these plans: *"No bodies this time, okay?"* said the neurodivergent child to his playmate. The playmates in Pair 2 also worked together to position objects and their bodies in front of the camera without their faces (Figure 4-7). The neurotypical child brought his shirt close to the camera and said, *"Now,"* and the neurodivergent child tapped the shutter button. For Pair 7, the neurotypical child verbally and physically helped the neurodivergent child position his block in front of the camera while he stood behind the iPad. The children laughed and smiled in these instances.



Figure 4-7. A pair of playmates covering the lens during a no tech-enforcement condition, so their faces and bodies were not in the picture.

Finally, technologically enforcing cooperation caused issues for one dyad, Pair 1, in another way I did not expect. The neurotypical child of Pair 1 realized he could trick his playmate by keeping his face within the

frame to keep the camera shutter button enabled; then, right before his playmate tapped the button, he would move his face out of the view, disabling the shutter button. While the neurotypical child was having fun breaking the rules and teasing his playmate, the neurodivergent child understandably became incredibly frustrated. This child's mother mentioned, "*[My child] is very interested in rule following and being fair/sharing. He liked [this version] because there were clearer rules...but was frustrated that his buddy [was not] following them.*" Later on she said, "*He's irritated. He would really enjoy this game if his buddy cooperated,*" and, "*I'm getting irritated too.*"

4.2.2 Effects of Prompting on Inclusive Play

The involvement of a character in the prompts did not considerably change children's experiences with the application. There was no significant main effect of prompt type on affect, $F(3, 12) = 0.202, p = 0.98, \eta^2 = 0.15, 1 - \beta = 0.078$ (Figure 4-8). There was also no main effect of prompting type on the frequency of synchronous reciprocal interactions between conditions, $F(3, 4) = 2.36, p = 0.170, \eta^2 = 0.250, 1 - \beta = 0.263$. However, there was a larger difference in the percentages of time with synchronous reciprocal interactions between prompting conditions than there was between enforcement conditions (Figure 4-9). Dyads were engaged in synchronous reciprocal interactions for 36.9% of the time on average during basic prompting conditions (SD = 28.1%) compared to 26.9% of the time on average during character-prompting conditions (SD = 25.1%). However, again, there was extreme variation across the pairs. Additionally, the children had to listen, and thus *not* interact with each other, for longer amounts of time during the character-based prompting conditions, since there was more text/audio for the character to say. This could have skewed the results to be biased toward basic prompting in this case.

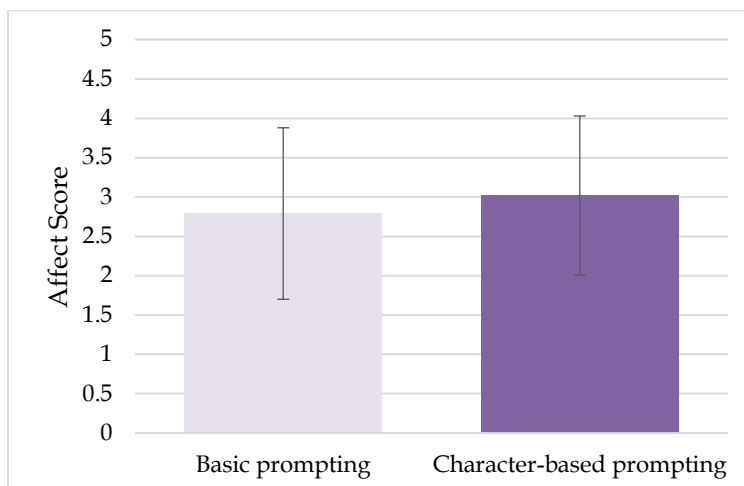


Figure 4-8. Average affect scores across participants over time, comparing conditions with basic prompting and character-based prompting (0-1: negative, 2-3: neutral, and 4-5: positive). Error bars represent \pm one standard deviation.

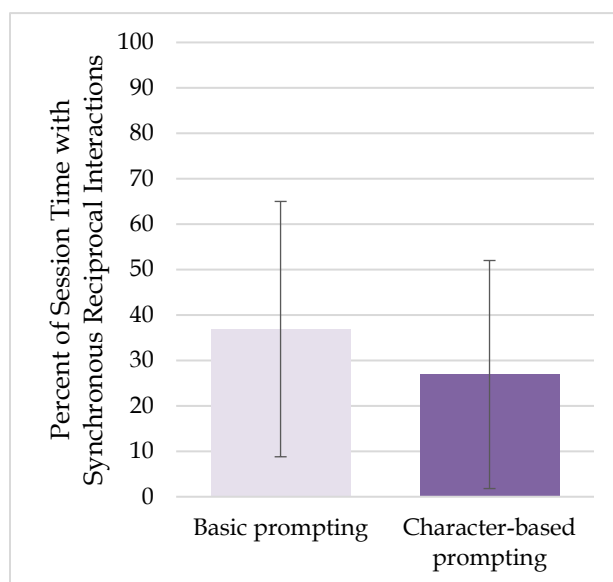


Figure 4-9. Average percent of session time with synchronous reciprocal interactions across dyads, comparing conditions with basic prompting and character-based prompting. Higher value indicates more synchronous reciprocal interactions during play. Error bars represent \pm one standard deviation.

Qualitatively, the results reflected this lack of effect of prompting on the children's experiences. In a few cases, a child mentioned the name of a character. For example, the neurotypical child in Pair 6 repeated the name "Alexis" after meeting the Alexis character, and the neurotypical child in Pair 1 repeated the name "Tobin" (AKA Toby) after meeting the Toby character. This same child also asked, "[S]he bites? [S]he bites?"

after character Mia said she was working on using her words instead of hitting or biting (Figure 4-10). Both children in Pair 6 made sounds (i.e., “Ooooh!”) when hearing about this specific anecdote about Mia too.



Figure 4-10. Screenshot of Mia’s introduction, story, and question in Includle 1.0.

Moreover, the faces on the main screen that demonstrated different emotions appeared to be more memorable than the cameras, as they enabled children to choose new topics that they remembered they had not completed in the prior character condition. Some children verbally associated the faces with the characters’ names and the emotions, demonstrating both memory skills and social and emotional awareness. Nevertheless, the neurodivergent child in Pair 4 said she liked the fact that it was more of a surprise for which prompt they would get with the cameras on the main screen.

4.2.3 Other Findings

In addition to the hypothesized features, Includle had other design features that supported children with inclusive play. Overall, it appeared that the topic had a greater impact on whether or not the children answered the questions prompted by Includle. For instance, the majority of the children answered what their favorite colors were. This makes sense, considering answering a question about your favorite color or shape is easier and likely more common for children. It also makes a person less vulnerable than answering questions like, “*What makes you feel sad?*”

An embedded support within the game was button tapping, which provided an opportunity for the children to practice turn-taking, although some pairs were more successful at this than others. In some

cases, the more play-dominant child, who we determined through qualitative analysis as regulating, controlling, or directing the play (in 5/8 pairs, this was the neurotypical child), became impatient with his or her playmate and took complete control of tapping buttons. In Pair 7, the neurotypical child repeatedly tapped the redo button when the neurodivergent child wanted to move onto a new topic. The playmates in Pair 5 rushed their hands to the iPad screen to get to the buttons first, going as far as to hovering their hands over the screen so that they would be ready to tap first when buttons appeared. The neurotypical child's mother in Pair 5 mentioned, "[My child] wasn't sharing well... She kept pushing the picture button." She went on to ask, "[Is] a sharing component possible?"

However, with other dyads, the embedded support for turn-taking led to cooperation between the two playmates. The neurotypical playmate in Pair 3 regulated turn-taking by explaining when it was her turn ("*my turn*") and when it was her playmates ("*your turn*"). Moreover, the children in Pair 8 did not have trouble sharing and also self-regulated without verbal interactions when tapping buttons.

Picture-taking also enabled cooperation between playmates and for the play-dominant child to be a peer support for his or her playmate. Prompting the children to take pictures with objects led to negotiation and cooperation. Children often shared blocks and other objects with each other. In some instances, holding an object made sure that both children had to cooperate to take a picture. For example, in Pair 6, the neurotypical child held a block in front of the camera while the neurodivergent child tapped the shutter button.

Prompting the children to make different faces for the pictures not only led them to consider and model what emotions look like, but it also allowed them to connect with their playmates and be peer models. The children often copied each other's positions and faces when taking the pictures (Figure 4-11). The children in Pair 4 both crossed their arms in most of the angry and frustrated pictures as initiated by the neurotypical playmate. Pair 4 laughed as they made silly faces and did not follow the directions by making funny and happy faces for the sad and embarrassed prompts.



Figure 4-11. A pair of playmates copying each other's poses.

The immediate review of pictures acted as a way to reflect, often with smiles and laughter, on the children's prior interaction with the game and each other. *"It looks like I have a beard,"* said the neurodivergent child of Pair 4 while both children laughed. The neurodivergent child in Pair 2 said, *"Look at us [and] our faces,"* and his playmate pointed at the picture and said, *"That's mine."* Pair 8 smiled at their pictures and each other after looking at their pictures too.

4.3 DISCUSSION

4.3.1 *No Technology-Enforced Cooperation vs. Technology-Enforced Cooperation*

The first sub-question RQ3-1 asked: does technology-enforced cooperation lead to more successful inclusive play compared to no technological enforcement? While I posited that (H1) tech-enforcement would lead to more successful inclusive play, the answer is not a clear yes or no. Technology-enforced cooperation changed the ways in which children interacted with my application and with each other. Generally, I found that technology-enforcement helped children take pictures together when they had a difficult time cooperating without enforcement. Yet, technology enforcement was unnecessary for children or during periods of play when they were cooperating with picture taking. In addition, there were tensions

between these rules and free play; this makes sense, considering pushing boundaries and rule breaking are part of play and child development (Bateson & Martin, 2013; Kuczynski & Kochanska, 1990). Both findings most likely explain why children had more positive affect in the no technology-enforcement conditions and no differences in synchronous reciprocal interactions. For instances in which the children did not need scaffolding, the enforcement limited their creativity and the non-enforcement version of Includle was more fun to play. For those who had trouble cooperating, the requirement that they had to cooperate, without explaining why it was important, made the experience less fun. Affect and engagement with the application may have directly influenced synchronous reciprocal interactions; when the children were not having as much fun or not using Includle together, they were not interacting with each other in the same way.

Most importantly, understanding how children can use or misuse these mechanisms of enforcement can help designers create applications for inclusive play. Piper et al. (2006) reported on the challenges that technologically enforcing turn-taking caused in one of the groups when a child consistently refused to cooperate with the enforced rules and delayed gameplay. On the other hand, Boyd et al. (2015) described how one child in a dyad consistently dominated turn-taking when it was not enforced. Related to both of these issues, Boyd et al. (2015) suggest that technology or a human facilitator must help enforce turn-taking, yet they highlight that it is still an open question for designers on how to facilitate cooperative interactions “without overly prescribing them.” I also lean toward a middle ground.

Ultimately, technologically enforcing cooperation *alone* is not enough to wholly support young children with inclusive play. In the case of this study, being more transparent throughout the play about why the enforcement is important, in both picture-taking and turn-taking (i.e., to help the playmates cooperate and play together), would likely help children collaborate and learn play skills. Instead of being dichotomous and either enforcing or not enforcing cooperation, the application could be more adaptive. It should explain why cooperation is important to contextualize enforcement. For instance, when two faces are not recognized, the application could suggest the playmates work together in the next picture. Giving the

ability of assisting adults to toggle on and off enforcement could also be more adaptive to the abilities and needs of pairs of children as well.

4.3.2 *Basic vs. Character-based Prompting*

The second sub-question RQ3-2 asked: does character-based prompting lead to more successful inclusive play than more basic prompting techniques? The involvement of characters in the application did not have substantial quantitative or qualitative effects on inclusive play between the dyads of children in the study. While I expected (H2) that having a human character who explained some aspects of an emotion and his or her experience with that emotion through plain text, spoken words, and a static image would lead to more positive interactions (like talking, answering questions, play cooperation, or other connections between the children), this was not the case. There were slightly more synchronous reciprocal reactions for basic prompting; however, this may be due to the fact that children spent less time facing and listening to the characters in the basic prompting condition, so they had more opportunities to interact proportionally. In response, I recommend keeping character dialogue shorter to increase opportunities for children to interact with each other.

Based on the related work, incorporating characters into interactive technology can support children with inclusive play; although, it could be optional if resources are constrained. There may be more complex ways that characters could make a positive effect on children that might also overpower the particulars of social and emotional learning content (i.e., children answered fewer personal questions, as in what their favorite color was as opposed to what makes them feel scared). The inclusion of popular or familiar characters, deeper stories behind the characters' experiences, accompanying animated video, interactive story elements, and/or interactive characters will likely lead to more positive affect and stronger connections between children. Additionally, because some children recognized the character faces or reacted to their stories, it is possible that longer-term usage with the application could lead to observable social and emotional learning, including an appreciation of the characters and their stories and a greater understanding of particular emotions.

4.3.3 *Photography*

This study also revealed the potential for interactive picture-taking of objects and faces as a successful way to facilitate inclusive play. There are various social and emotional training applications that promote rote learning of what emotions look like (e.g., Baron-Cohen, Golan, Wheelwright, & Hill, 2004; Bölte et al., 2002; Tanaka, Lincoln, & Hegg, 2003). However, for inclusive play, a system that is more interactive is appropriate. Byrnes and Wasik (2009, p. 247) explain it is helpful for young children to have “actual pictures of themselves demonstrating different emotions and feelings so that they can think and talk about feelings in relation to themselves and their own experiences.” Thus, to be more interactive, inclusive social and emotional learning applications can have the option to use players’ own faces. Doing this with a playmate effectively allows for collaboration and joint reflection too.

4.3.4 *Limitations*

There are several limitations in this work. First, the Latin Square was uneven, so the order of conditions was not perfectly balanced in the sample. Next, unfortunately parents did not report on their neurotypical children’s prior experiences with children with disabilities or any measure of their level of empathy or understanding of disability, which may have acted as a confound. Additionally, here, I did not report on nor unpack the impact of other intersectional aspects of children’s identities (e.g., race, ethnicity, socioeconomic status, religion, etc.) on children’s interactions with Incloodle. Furthermore, although it allowed me to control for differences between the participant pairs, the limited adult intervention in the study and the fact that the children were complete strangers may not be as ecologically valid as having children who know each other play together in a natural setting. Finally, because the lab study session durations were short, I was not able to test longer-term impacts on children’s behavior, social and emotional learning, and/or changes in children’s acceptance of diverse individuals, including those with disabilities. The goal of my field intervention with Incloodle (Chapter 5) aimed to overcome some of these limitations.

4.4 SUMMARY OF CONTRIBUTIONS

This study sought to address whether certain design features result in interactions between children that are indicative of successful inclusive play more than others. The results revealed the ways that using technology to enforce cooperation changed the inclusive play experiences of children with differing needs in both more positive and more negative ways. While I did not find substantial effects of character-based prompts on children's experiences, there is more work to do to understand how characters and narratives within technology can facilitate inclusive play. Given these results, there are key takeaways both on how technology designers might conceptualize inclusive play – i.e., as fluid joint participation between children with diverse abilities and needs that needs contextualization and adaptations – and how technology might be designed in this area – i.e., with a balance of open-endedness, adaptation, and the ability to individualize or contextualize experiences either technologically or with external human support.

Overall, I contribute Incloodle as an artifact to promote possible, preferable futures, embedding within it an understanding of what inclusion may mean for collaborative play technology design. I also contribute an empirical evaluation of interactive technology for inclusive play and offer guidance for designing technology that facilitates inclusive play between young neurotypical and neurodivergent children. Based on this empirical evaluation, the next step in my work involved iterating on Incloodle 1.0's design such that it can better adapt to the needs and abilities of children. Incloodle can support children more inclusively with options to moderate enforcement, the involvement of more interactive story-elements, and more transparency regarding disability, which I address in the next chapter.

Chapter 5. INCLOODLE 2.0: TECHNOLOGY FOR INCLUSIVE PLAY IN A KINDERGARTEN CLASSROOM

In the final phase of my dissertation, I redesigned Incloodle to use the application as an intervention in an inclusive classroom. I studied how neurodiverse kindergarteners co-played with the application in a more natural setting and over a longer period of time than my prior investigation with the prototype in a laboratory. This work aimed to answer RQ4: *How do interactions between neurodiverse children, technology, and adults shape inclusive play in a formal learning environment?* As part of this larger question, I asked two main interrelated sub-questions: (RQ4-1) *What types of interactions among neurodiverse children (that were or were not necessarily designed for) emerge over time with this type of collaborative play with tablet technology and adult support?* And (RQ4-2) *How does this joint socio-material context engender or restrict equitable engagement and participation (i.e., inclusion) over time? In this context, who and what does the ‘including’ (or ‘excluding’)?*

In this chapter, I overview the redesign of Incloodle and the details of my intervention with Incloodle in an inclusive classroom. Then, I describe the findings of my interaction analysis of the video data I collected during the intervention and discuss how these findings inform the answers to my research questions.

5.1 INCLOODLE 2.0 DESIGN

The results of the lab-based evaluation of Incloodle 1.0 (Chapter 3) indicated the impact particular features of the application had on neurodiverse pairs of children when they played with it together in a controlled setting. For neurodiverse children to use Incloodle in a natural inclusive environment, I needed to adjust aspects of Incloodle’s technological enforcement and character-based content, in addition to iterating on the design of the application as a whole to sustain children’s longer-term engagement.

In Incloodle 2.0, each child has their own “account” which the child or an adult can choose from the start page of the application (Figure 5-1). When two children have been chosen, they can enter into the main screen to begin playing (see Figure 5-2 for wireframes of the interaction flow; see Figure 5-5 for screenshots).

From this main screen, there are five characters to “meet” (Figure 5-5, A) who, when chosen, tell the playmates anecdotes about themselves and prompt the children to talk to each other about different social and emotional learning topics (Figure 5-5, B-D). The children then take pictures of themselves together making faces or with objects that relate to the topics (Figure 5-5, E-F).

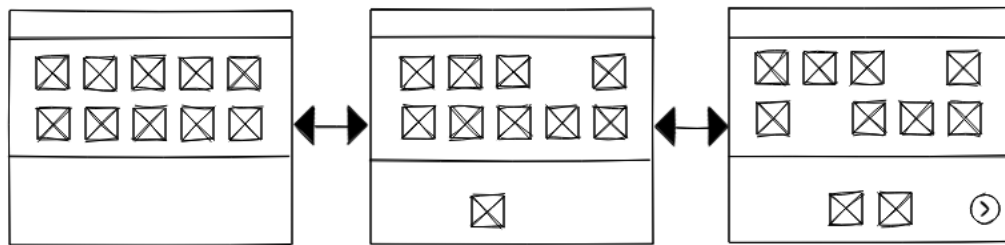


Figure 5-1. Wireframes and interaction flow for account login experience in Includle 2.0. Each box represents an image of a child (i.e., an account).

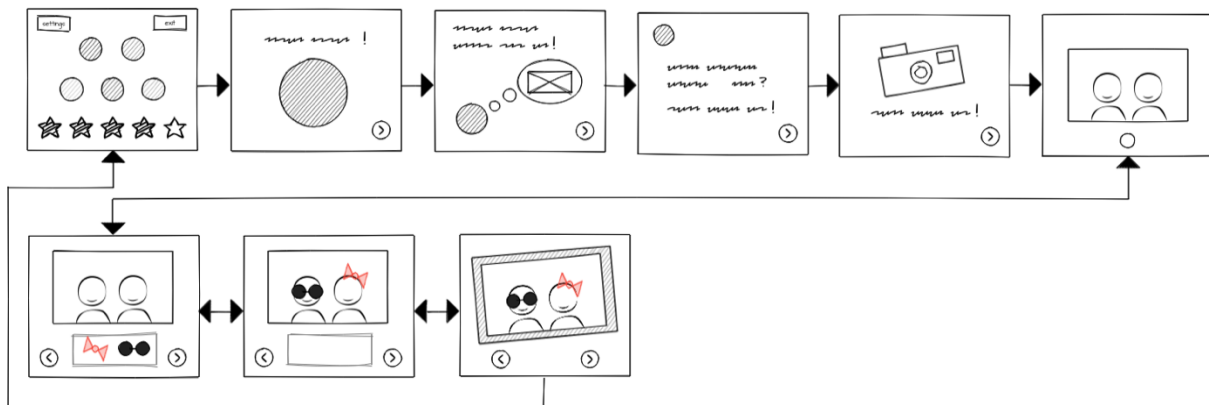


Figure 5-2. Wireframes and interaction flow for main play experience in Includle 2.0.

After, they can decorate their pictures with stickers (Figure 5-5, G). Each time the playmates “meet” a character, it moves down to a star at the bottom of the screen (to show the play progress) and is replaced by a new character (Figure 5-5, A). Once the playmates “meet” five characters, and consequently take five pictures together, filling up the five stars of the progress bar, the children can print two copies of one picture to a wireless (AirPrint) printer for each of them to keep; Figure 5-3 shows the interaction flow of picture selection and shows examples of printed photos.

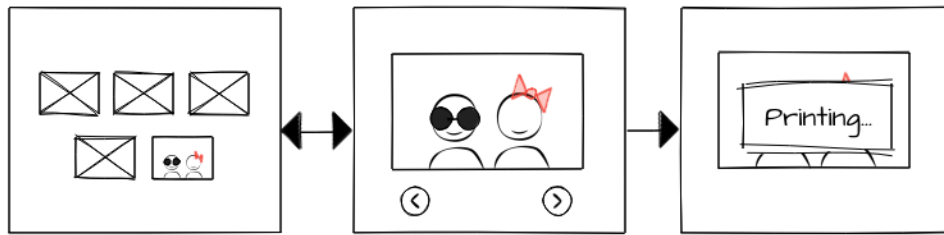


Figure 5-3. Wireframes and interaction flow for choosing and printing picture in Includle 2.0. Boxes represent other pictures taken by playmates.

In relation to technology-enforced cooperation for picture-taking, I implemented a toggle that allows an adult to turn on or off the enforcement from a settings screen (Figure 5-4). Here, the adult can choose whether or not a pair of children need this type of embedded support during their play. Concerning character-based prompting and content, with the help of two other designers, I updated Includle 1.0's characters and developed new characters and stories, resulting in 25 total (see Appendix A, Appendix Table 2 for a complete list of the characters and stories in Includle 2.0).

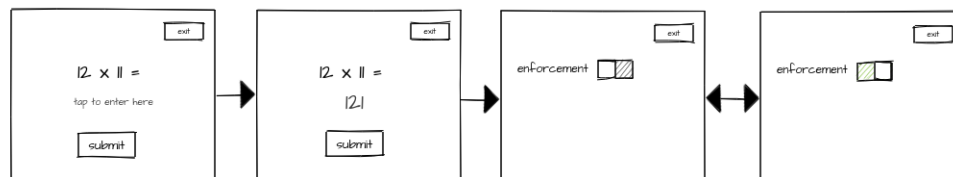


Figure 5-4. Wireframes and interaction flow for changing settings options (i.e., turning on or off technology-enforced cooperation in picture-taking) in Includle 2.0.

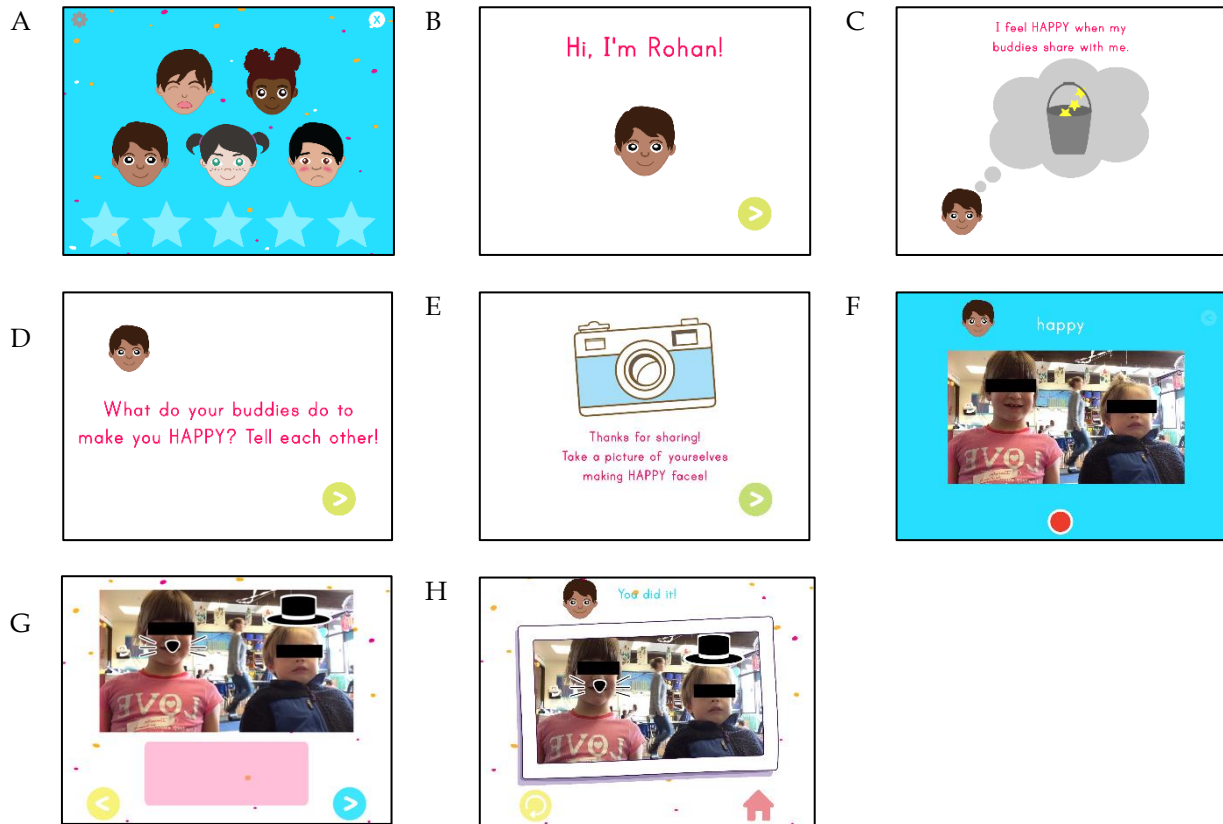


Figure 5-5. Includle 2.0 main play screenshots, ordered chronologically, top to bottom, left to right. Original character images by © Liz Aragon. Updated characters by Lucas Colusso and Mackenna Lees.

I programmed the updated app prototype in Swift 3 within Xcode 8.3.3. The application now operated on an iPad Air 1, running iOS 10.3. The wirelessly connected printer was a ZINK hAppy printer (Figure 5-6, left), which does not require ink cartridges, and prints pictures as stickers on rolls of ZINK (or zero ink) printer paper, ranging from 0.5" to 2" in width (Figure 5-6, right).



Figure 5-6. Printing photos. *Left*: ZINK hAppy printer. *Right*: Examples of ZINK printer photos.

5.2 METHODS

5.2.1 *Participants, Setting, & Data Collection*

Over the course of ten weeks (January – April 2018), I brought³ Incloodle 2.0 two times per week to two combined inclusive kindergarten classes that were comprised of 31 students. Fifteen of these students had Individualized Education Plans (IEPs) and were diagnosed with disabilities, such as autism, developmental delays, and “other health impairments.” As gathered from their diagnoses and IEPs, all 15 of these students are considered to be neurodivergent.

Play sessions with Incloodle occurred during free play time in the classroom and lasted about 45 minutes to one hour. During the sessions, pairs or triads of children (and sometimes more) played Incloodle on an iPad with a child-friendly case while sitting at a table with the iPad positioned in front of them on a stand (Figure 5-7, right). The iPad was on a stand to ensure that children had their hands free, as opposed to holding the tablet or worrying about tilting it to a particular angle to capture their faces. Groups of children played with Incloodle for as long as they desired and/or up until they were able to print a picture (usually 8-15 minutes). Some children played for as long as 20 minutes or for as short as four minutes (i.e., stopping before getting to print pictures). Thus, events—or “stretches of interaction that cohere in some manner that is meaningful to the participants” (Jordan & Henderson, 1995, p. 57)—occurred from a neurodiverse group’s start of play with Incloodle to their end of play, which was usually designated by the children receiving their printed pictures.

At the beginning of the intervention, children were asked to play with Incloodle in assigned pairings/triads by teachers in a certain order and then children assented to participate. After almost all of the children had a chance to play with Incloodle using this method, children then mainly “signed up” to play with Incloodle as a personal choice, unless teachers personally requested they participate. In this case, a teacher might

³ While I installed Incloodle 2.0 onto a classroom iPad, the teachers informed me that the children did not play with the application when I was not present.

request particular children/pairs participate because playing with Incloudle was somehow tied to a child's or children's play plan or a child's individual goals. At this point, children were either able to pick their own play partners for Incloudle, or they were assigned "buddy pairs" or "buddy groups" already for the day and played with Incloudle in this same pairing or group. Due to this variable process of choosing/assigning playmates, children were not always in neurodiverse pairs or groups when co-playing with Incloudle.

Teachers in the classroom sometimes, yet much more rarely due to their other responsibilities in the class, interacted with or helped the children while they were playing with Incloudle. Rather, as someone who had volunteered in this classroom in prior years and knew the teachers from this experience, I was trusted with and expected to facilitate the children's play. Therefore, in addition to the children and teachers in the classroom, I am also an interactant in many of these sessions and, hence, also part of the socio-material context.

Two video cameras recorded the children playing with Incloudle, which started and stopped with each play event. This resulted in a total of 84 distinct recordings of play events, totaling about 837 minutes or 13.95 hours of video data. One camera faced the children's faces and one faced their backs with some view of the tablet screen (Figure 5-7). Incloudle also saved every picture the children took together during these play events onto the tablet's camera roll (as seen in Figure 5-5, F-G).



Figure 5-7. How video was recorded during intervention. *Left:* Camera facing faces. *Right:* Camera facing backs.

As play with Incloudle happened in the same way that typical technology-based activities occurred in the classroom (i.e., students already played with iPads in the classroom), as per the Institutional Review Board and the school, parents did not have to consent for their children to participate in this study. In this way, all children in the classroom had the same opportunities to play with the tablet, with their assent. However, I sent home information sheets about the study to parents with my contact information. I also included a media consent form, which parents could send back signed to consent to have their children's images used in public presentations and publications. As a token of appreciate for their children's participation, at the end of the study, I sent home thank you notes and copies of the book *We're Amazing 1, 2, 3!* with every child in the classroom. *We're Amazing 1, 2, 3!* by author Leslie Kimmelman and illustrated by Marybeth Nelson is a Sesame Street Big Golden Book about Julia, a new Sesame Street Muppet with autism.

5.2.2 *Data Analysis*

Guided by my research questions (RQ4: RQ4-1, RQ4-2), my analytic approach for this study followed that of my theoretical framework, specifically drawing on multimodal interaction analysis (Norris, 2004) and video research in the learning sciences (Derry et al., 2010). My data was comprised of video data, ethnographic notes and memos I made during the intervention, and the pictures that the children took together on the tablet's camera roll.

As mentioned previously, there were 84 distinct play events captured in video; however, in relation to my research questions, my analysis mainly focused on the 45 play events that involved at least one neurotypical child and at least one neurodivergent child. Twenty-four of the play events only included play between two or more neurotypical children; and 15 events only included play between two or more neurodivergent children.

Another researcher and I began by content logging the play events in which at least one neurodivergent and one neurotypical child played with Incloudle together. Then, we took a grounded approach to open coding our content logs (Corbin & Strauss, 2008), discussing and revising the codes throughout the analysis

until we came to consensus. After each coding half of the content logs, we reviewed and updated each other's analyses. During this process, we also utilized my ethnographic notes and the camera roll pictures to supplement our developing arguments, either matching or contrasting with emerging patterns in the data.

This analytic process resulted in 55 sub-codes, which we organized into 6 overarching codes: adult involvement, equitable participation, inequitable participation, verbal communication, reflection/connections, and positioning for inclusion/exclusion. While content logging, coding the data, and organizing our sub-codes, we made analytical notes in the content logs of "hot spots" or key interaction sequences that identified patterns and built on our emerging arguments.

I then transcribed these sequences, which were strategically selected for deeper analyses to identify and examine consistent and contrasting patterns (Derry et al., 2010), reflecting on the fact that transcription is underpinned by my theoretical foundations, guiding research questions, and goals (Ochs, 1979). My transcripts integrate verbal and non-verbal behavior. They not only include the human participants as interactants but also Incloodle as an interactant as well. Additionally, they utilize the transcription conventions from Jefferson (2004) (see Appendix B for specific conventions used). These transcripts also integrate snapshots of the interactions to display multimodal interactional patterns and embodied communicative modes (Norris, 2004). Besides my own, all names in the transcripts and in the discussion of the interaction sequences are pseudonyms.

Throughout logging, transcription, and analyses, the other researcher and I focused on child-Incloodle / Incloodle-child, child-child, and adult-child / child-adult interactions (e.g., orientation, posture, gesture, talk, etc.) as *analytical units*. In this way, we examined *participation structures*—or "fluid structures of mutual engagement and disengagement," characterized by body positioning, eye contact, tone of voice, and other situationally appropriate resources (Jordan & Henderson, 1995, p. 67)—in relation to my designed technology. Centering around these participation structures allowed us to study "the C-issues" to which

Jordan and Henderson (1995, p. 69) refer: “cooperation, conflict, conviviality, competition, collaboration, commitment, caution, control, coercion, coordination, co-optation, combat, and so on,” which are significant in regard to equity and inclusivity. In the section that follows, I examine a series of illustrative interaction sequences to exemplify how Includle consistently structured children’s inclusive play, shaping what it meant to be inclusive (or exclusive) and equitable (or inequitable) in this socio-material context.

5.3 FINDINGS

In this section, I break down my findings according to five significant themes, which I describe using a narrative-oriented approach with illustrative transcripts (Derry et al., 2010). I begin by explaining how the characters’ stories in Includle could be resources for reflection on and connection to children’s own qualities or qualities of their classmates. I then explain how children followed or did not follow the prescribed structure of Includle, impacting their interactions with each other and with Includle. Next, I demonstrate the ways in which children negotiated their physical and virtual space, as constrained by Includle’s camera view, and subsequently I discuss how adults are intertwined in the socio-material context of inclusive play with Includle. Finally, I describe how printing pictures was significant to and reinforcing for children, and I show how pictures became “proof” of inclusion (or exclusion), sometimes distinct from the interactions that happened behind the picture.

5.3.1 *Connections and Reflections on Children’s Characteristics and Experiences*

In the laboratory study with Includle 1.0, the characters, their anecdotes, and prompting did not have a significant positive influence on children, their interactions with each other, nor their engagement with the application. Yet, in this setting in which the children were more familiar with each other, the characters in Includle provided interactional space for the children to think and talk about the social-emotional content presented as it related to their own or each other’s lives. Not every character or story was successful in prompting every group of children to reflect or connect on social-emotional topics; in fact, the most answered questions were those with more straight-forward answers, unrelated to particular emotions (e.g.,

What are your favorite colors? What are your favorite animals? What are your favorite numbers?). However, in the instances where this deeper reflection did happen, children had poignant verbal answers to questions and displayed meaningful, embodied understandings of particular emotions in their pictures.

In a key interaction sequence between children Anna and Russell, Incloodle's character Charlotte presents a story about what makes her feel left out, and then asks the children to talk about what makes them feel left out (Transcript 1, line 1). Anna ignores the question and begins making a funny face toward the tablet (line 2). Contrastingly, Russell takes a moment to think about the question and answers a related question about what makes him sad (line 3), while Anna looks at him. Looking back at the screen, Anna responds to Russell to say she also feels sad in the same situation (line 4). As Incloodle goes on to prompt the children to take a picture of themselves, Russell ignores the audio and goes on further to explain what happens when he feels sad (line 7). Anna, who stops herself from going to the next screen, looks to Russell and listens (line 6). While pulling his shirt up to his chin over his mouth, Russell explains he covers himself up when he feels sad: "I make myself INSIDE me." After moving to the camera screen, Anna and Russell look at themselves through the screen for a second and then Russell puts his shirt up over his face (line 8). Anna sees what Russell is doing through the camera view onscreen, rather than by looking directly at him. She smiles and copies Russell by putting her shirt up over her face for the picture (line 9; resulting picture on line 11).

1 Includle: What makes you feel left out? Tell each other!

2 Anna: ((Starts to make a funny face but stops. Looks at Russell while he talks.))



3 Russell: When my mom picks me up, I feel really sad. ((Presses next button.))



4 Anna: ((Responding to Russell but looking at screen.)) Me too.



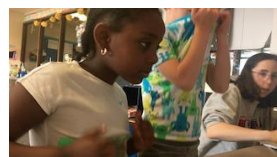
5 Includle: [Thanks for sharing! Take a picture of yourselves making the face you have when you feel left out!]

6 Anna: [((Goes to press the screen but stops and brings her hand back in when Russell starts to talk. Looks at Russell.))
]



7 Russell: [((Looking at Anna.)) I cover myself. ((Brings his shirt up over his mouth and back down. Reaches out to press the next button.)) I make myself INSIDE me.] ((Presses next button.))

8 Russell: Hide myself. ((Puts his shirt over his face.))



9 Anna: [((Sees Russell's action through the camera screen. Smiles. Puts her shirt over her face.))
]



10 Kiley: [((Reaches over to the tablet.))] One... two... three! ((Presses shutter button.))

11 Includle: ((Makes camera sound. Takes picture.))



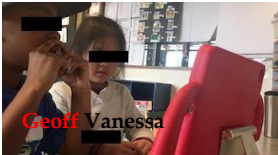





Transcript 1.

Here, we see two important yet contrasting interactions from the two children. Russell uses the prompts to reflect on his own emotions and experiences and explains and shows what he does (perhaps both metaphorically and physically) when he feels sad to Anna. During this time, he stands and is physically positioned toward Anna. Moving toward the screen, Russell then uses his embodied emotion of hiding for the “feeling left out face” picture. At the same time, Anna is less engaged with the question posed by Incloodle yet also more often oriented toward the tablet, as opposed to physically positioned toward Russell while he talks. Still, Anna consistently interrupts herself from interacting with Incloodle to listen to Russell. She hears Russell’s answer and agrees (“Me too.”), and when actually seeing Russell’s pose for the picture *through* the camera, she copies it, displaying an embodied understanding of Russell’s experience through her mimicking. In this interaction sequence, Incloodle acts as a resource for inclusive play, prompting reflections for Russell, inhibitory control and empathy for Anna, and a joint embodied understanding of sadness through picture taking for both children.

In another play event with two neurotypical children (Transcript 2), Geoff and Vanessa, Incloodle plays a similar role, providing basis for reflection and connections to, in this case, some of their neurodivergent classmates. After Lexi says that she feels angry when sounds are too loud because they hurt her ears (line 1), Geoff turns his head swiftly toward me and excitedly exclaims that his classmate (who is neurodivergent) feels angry in the same situation (line 2). When I respond by saying, “Oh, yeah?” (line 4), both children concur by saying “yeah” (line 5-6). Even after they move onto the next screen, Geoff thinks of another (neurodivergent) classmate who has a similar sensitivity to sound (in fact, this child often wore noise-cancelling headphones in the classroom) and enthusiastically tells me this as well (line 9).

While neither Geoff nor Vanessa answers the question or otherwise engages with each other in relation to the question about themselves, Geoff relays information that he knows about his classmates’ sound sensitivities, to which Vanessa agrees. Thus, rather than (only) prompting reflection on their own feelings or experiences, Incloodle allows children to associate what they know about their friends to the character within Incloodle. This is important as evidence that the character content in Incloodle, though somewhat

simple in graphical representation and with short anecdotes, can provide learning opportunities and connections between children's knowledge about the diverse experiences, abilities, and needs of the people around them to what is presented in the application.

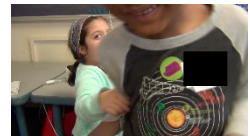
1	Incloodle: I feel angry when sounds are too loud because they hurt my ears!	
2	Geoff: ((Turns head away from the screen to look at Kiley.)) That's how Kevin is (:) when sounds are too loud!	
3	Vanessa: ((Looks up at Kiley.))	
4	Kiley: Oh, yeah?	
5	Geoff: Yeah.	
6	Vanessa: ((Reaches out to press the next button)) Yeah.	
7	Geoff: ((Reaches out to press the next button.))((Gets to the button before Vanessa.))	
8	Incloodle: What makes you feel angry? Tell each other!	
9	Geoff: And Andy!	
Transcript 2.		

5.3.2 *Making Sense of and (Not) Following Incloudle's Prompts*

In the laboratory study with Incloudle, child pairs either followed the prompts of the application to take pictures making certain faces or with certain objects or they did not. Sometimes, when children did not follow the “rules” of the picture-taking prompts, they had more fun; they covered up the camera, did not put their bodies in the picture, or deliberately made faces that did not match what Incloudle was telling them to do. In the case of the intervention study, children had the chance to play with Incloudle multiple times over multiple weeks, learning about how Incloudle worked and demonstrating their understanding of what they were supposed to do or what they wanted to do, in line with or despite the prompts (e.g., through dominating interactions and/or trying to teach their play partners). In this way, Incloudle became a semiotic resource that gave both interactional rules and goals for children and elicited subsequent responses from and interactions between children.

For example, in Transcript 3, Incloudle’s character Ashley prompts Lisa and Adam to take a picture with a circle (line 1). As Adam had played with Incloudle in the past, he knows through this play that Incloudle (or I) want the play partners to take pictures with objects that match the prompt. Adam gasps, stands up, and tries to explain to Lisa that they need to find circles to put into the pictures (lines 3, line 5), yet Lisa, who is the more dominant driver of the interaction with Incloudle, is not convinced. She does not change her positioning (line 4) until Adam begins to walk away (line 5). At this point, she grabs Adam’s arm to bring him back to Incloudle to take the picture, essentially demanding that he do so (line 6). While Adam continues to stand, I intervene to explain Adam’s line of action (line 9), which gives way to Adam being able to leave to find a circle (line 10). Not until I question Lisa about finding a circle (line 11) does she respond. Still, she decides she wants to find something of a *different* shape, her favorite shape (as she explains earlier in the play event), a heart (line 12).

- 1 Incloudle: Thanks for sharing! Take a picture of yourselves [with my favorite shape, a circle!]
- 2 Lisa [((Brings both hands to iPad.))]
- 3 Adam: ((Gasp)) We need to find a circle! ((Gets up, away from chair.))
- 4 Lisa: ((Still hovering her finger over the screen, waiting to press the button. Presses it.))
- 5 Adam: We need to find a circle ()! We need to! ((Starts to walk away.))
- 6 Lisa: ((Reaches to grab Adam's arm.)) () Take a picture!
- 7 Adam: ((Turns and walks a bit back toward Lisa.))
- 8 Lisa: ((Lets go of Adam's arm.))
- 9 Kiley: ((To Lisa)) Oh, I think he was gonna go find a circle to put into the picture.
- 10 Adam: [((Walks away.))]
- 11 Kiley: [((To Lisa)) Do you want to grab something that's a circle shape to put in the picture?]
- 12 Lisa: ((Starting to get up.)) I need to grab something, um, something that's a heart. ((Looking at a student approaching the table.))



Transcript 3.

During this interaction sequence, Lisa and Adam go back and forth, verbally and nonverbally, around the meaning they gathered from Includle's directions, whether informed by prior play (most likely the case for Adam) or perhaps ignored, misunderstood, or not heard at all (which may be the case for Lisa). Lisa asserts her dominance over the interaction with Includle and with Adam by physically moving him back to the interaction space, while I intervene to explain that Adam is "right" (or at least warranted) in his request/actions. Having already tried to tell Lisa about what they needed to do next—following the structure of the application and attempting to enforce that structure, Adam is ready to move on with his goal of finding a circle, walking away in two instances (line 6, line 10) when Lisa does not follow his lead. Yet, even after I specifically prompt Lisa to do what Includle asked, she reinterprets the task to fit her own idea of what the task should be.

Similarly, in Transcript 4, Includle's character Maya prompts Tristan and Jeremy to take a picture of themselves according to a particular directive—in this case, making grumpy faces (line 1). Jeremy begins making his own grumpy face (line 2, line 5) before the camera screen even appears; he keeps his mouth open, clenches his teeth, and slightly curls his upper lip. When Tristan gets under Jeremy's finger to press the next button, Jeremy's grumpy face subsides (line 7). Then, Tristan provides a model of what grumpy means here (line 7)—he opens his mouth to show his teeth, furrows his brow, and growls aloud. Following, Jeremy copies his play partner, making the same face and growling in the same way (line 8). Tristan presses the button to take the picture, again under Jeremy's finger, and the two playmates smile at the resulting picture (lines 11-12).

1 Incloudle: [Thanks for sharing! Take a picture of yourselves making grumpy faces.]

2 Tristan: [((Keeps hands on face.))]



3 Jeremy: [((Starts to make a grumpy face.))]

4 Kiley: Oooh, grumpy faces!?

5 Jeremy: [((Reaches to tap next button while starting to make another grumpy face.))]



6 Tristan: [((Reaches to tap next button while starting to make grumpy face.))] ((Taps button by getting under Jeremy's finger.))

7 Tristan: ((Growls with mouth wide open. Finger still hovering over the screen.))



8 Jeremy: ((Finger still hovering over the screen. Growls and opens mouth like Tristan.))



9 Tristan: ((Taps the shutter button under Jeremy's finger.))



10 Incloudle: ((Makes camera sound. Takes picture.))



11 Tristan: ((Points at the picture.)) ((To Kiley)) Is that a good one?



12 Jeremy: ((Smiling. Taps next button.))



Transcript 4.

Unlike the interaction sequence of Lisa and Adam in Transcript 3, the mirrored yet parallel actions of Tristan and Jeremy in relation to what Incloudle presents are fluid and embodied. Neither child explicitly or verbally states how they make sense of the prompt of Incloudle nor do they position themselves or look toward each other at all. Instead, they follow the instructions side-by-side with Jeremy ultimately copying the (inter)actions of Tristan with Incloudle. They engage with each other and with Incloudle in a collaborative way, while at the same time not necessarily cooperating with button pressing (lines 5-6, lines 7-8). Incloudle acts as a mediational tool and resource for Tristan and Jeremy, allowing them to equitably participate with each other *through* the joint interactional space around Incloudle without having to directly interact with each other.





















5.3.3 *Negotiation of Physical and Virtual Space*

Parallel to how the text and verbal prompts in Incloudle provided meaning, structure, and interactional space for engagement, the camera view in Incloudle structured and impacted how children interacted when taking pictures together. As Incloudle limited the space in which they could be “seen,” children had to negotiate both their physical and virtual space, as they, Incloudle, or I physically attempted to physically include them in the picture.

Before the interaction sequence of Transcript 5, Lisa and Adam were prompted by Incloudle’s character Ashley to take a picture of themselves with a circle (Transcript 3, line 1). After “finding” what they wanted to put into the picture (i.e., Adam’s circular object and Lisa’s hand heart gesture) (as seen in Transcript 3), Adam first positions himself in front of the tablet, and afterward Lisa walks up to Incloudle. Lisa immediately pulls down Adam’s hand holding the circular object (Transcript 5, line 1) to make room for herself and her heart gesture. Lisa positions her hands so that they are captured by the iPad camera (line 3); however, at this point, Adam and his circle are no longer included in the picture. I take notice of this and ask Adam if he wants to put his circle back into the picture (line 5). Following, he positions his circle back toward the iPad (line 6) but, in turn, blocks Lisa and her heart. Due to this obstruction, Lisa announces that she is being blocked and pushes Adam’s arm out of the way (line 8). I intervene to position Adam’s




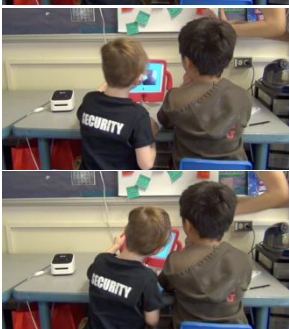



hand in such a way that would include his circle, Lisa, and her heart hands (line 9-12) and press the shutter button for them (line 13).

Here, we see a negotiation around physical space as dictated by what is included virtually in the picture. Both children try to *include themselves* and/or their objects into the picture itself yet, at least initially, struggle to make physical room for each other that would be reflected in the virtual space. It is also apparent in this interaction sequence that I, while not explicitly intended through my design process, became an active part of the Incloodle system. In this case, Incloodle dictated a goal—take a picture—which the children followed. Positioning in the real world became complicated and constrained as it was structured through the lens.

1	Lisa:	((Grabs Adam's arm that has the circle in hand and pulls it down.))		
2	Adam:	Ah! ((Laughs))		
3	Lisa:	((Sit down. Puts her hand fingers in front of the screen))		
4	Adam:	Luh, luh, luh		
5	Kiley:	That's your heart-Adam, do you wanna get the (-) circle in the picture? ((Reaches toward the shutter button.))		
6	Adam:	((Moves the circle back up to the screen.))		
7	Kiley:	One... twooo...		
8	Lisa:	Wait, you're blocking me. ((Moves Adam's hand away.))		
9	Kiley:	Here, let me help you, where to go.		
10	Kiley:	((Positioning Adam's hand with the circle in it so that it's in the camera view.)) Okay, let's put this one back here.		
11	Kiley:	((Continuing to position Adam's hand with the circle.)) And push it this way.		
12	Kiley:	((Holding Adam's hand in place.)) Alright, one... two... ah! Three! ((Presses button.))		
13	Incloodle:	[[((Makes camera sound. Takes picture))]]		
Transcript 5.				

Comparatively, Transcript 6 presents another, different instance of physical and virtual space negotiation. However, here the interaction sequence involves one play partner, Sam, working to orient the camera to include his partner, Howie, which contrasts the contingent struggle between Lisa and Adam in Transcript 5. After Includle's character Joey prompts the children (Transcript 6, line 1), Sam presses the button to the next screen where he and his play partner are supposed to take a picture making loving faces. For three seconds, he hovers his finger over the shutter button, waiting while both of the children stay in place to take the picture (line 3). Howie does not make any acts to move or interact with Sam nor Includle during this time. Through closer examination, one can see that the camera view only includes half of Howie's face in the picture (line 3); consequently, Sam pulls his hand away from the tablet (line 5) and tries to turn it toward Howie (lines 6). When the iPad almost falls off the stand, I step in (otherwise, not paying attention to the interactions at the moment, as I was trying to get the other video recording camera working again). Otherwise, Sam leads the interaction, pressing the shutter button and successfully taking a picture that includes both him and his play partner.

Again, in this sequence, we see a change in physical positioning to accommodate virtual inclusion. Yet, the interaction is driven by one play partner, Sam, while the other stays static, without speaking or moving. In this way, Sam becomes responsible for doing the "including" and deems what "counts" as being an appropriate picture for the two of them. Rather than moving Howie, like Lisa's approach to Adam, he changes the position of the tablet itself, ultimately reorienting the lens to be inclusive of their physicality in the moment.

1	Incloodle:	Thanks for sharing! Take a picture of yourselves making loving faces!	
2	Sam:	((Taps next button with finger.))	
3	Sam:	((Reaches for shutter button to take picture.)) ((Hovers over shutter button with finger.)) (3.0)	
4	Incloodle:	((Sam's face is fully in the picture. About half of Howie's face is in the picture.))	
5	Sam:	((Pulls hand that was hovering back. Turns a bit to the right.))	
6	Sam:	((Moves the iPad with his left hand, toward Howie. The iPad almost falls off the stand.))	
7	Kiley:	((Reaches in and helps put the iPad back into the stand so it doesn't fall.))	
8	Sam:	((While the iPad is now angled more toward Howie, Sam taps the shutter button to take the picture.))	
9	Incloodle:	((Makes camera sound. Takes picture))	
Transcript 6.			

5.3.4 *Adult Scaffolding as Integral to the Includle System*

While Includle gave structure for interactions between children, either through prompting of questions or by providing virtual cooperative space for picture-taking, it was clear that, particularly due to the diverse abilities and needs of children in conjunction with the open-endedness of Includle, adults (i.e., me or the classroom teachers) needed to support children's engagements and (inter)actions with each other and Includle in a significant way. As exemplified in Transcript 5, I, along with teachers in the classroom, consistently became entangled in the socio-material context of children's play.

Following what we know about the benefits of joint media engagement and scaffolding (Takeuchi & Stevens, 2011; Vygotsky, 1980) and adults' roles in facilitating inclusive play (Casey, 2005b), the other teachers and I helped in areas where the children needed support—physically positioning the iPad, mediating turn-taking and communication, providing additional positive reinforcement, or otherwise contextualizing their play. This scaffolding was most vital in two different situations. The first was in situations where the neurodivergent child in the pair had goals in their IEP related to specific behaviors (e.g., self-calming, self-regulation, flexibility, asking for help, negotiation, etc.) or communication (e.g., practicing verbal language, expressive non-verbal communication, and/or social non-verbal communication) and already received accommodations in the classroom related to those IEP goals (e.g., clear expectations of behavior, positive reinforcement for appropriate behavior, demonstration of instructions when introducing new tasks or content). In the second situation, the neurotypical child needed support in being more patient with or accommodating of their neurodivergent play partner. (This latter situation also matches technology enforcement's successful role in supporting inclusive play in the lab study in Chapter 4.)

An example of the first situation occurs in Transcript 7. In this interaction sequence, Claire (who is neurotypical) is playing with Gabe, who is non-verbal and currently working on his communicative language. A head teacher from the classroom sits down next to Gabe to assist him in playing while I sit and watch behind Claire. Includle's character Ashley asks the children what their favorite colors are (line 1),

and Claire answers, speaking directly to their teacher, rather than to Gabe (line 2). The teacher repeats what Claire says, and prompts them to think about what Gabe's favorite color could be (line 3). The teacher and Claire enter into a conversation back and forth during which the teacher offers different ideas about what Gabe's favorite color could be based on what he wears, and Claire looks back and forth from Gabe to the teacher (lines 4-9). Here, we can begin to see the work of the teacher to include Gabe in an inaccessible part of Incloudle; Incloudle prompts the children to talk to each other verbally, not allowing them to use the screen as interactional space to answer the questions through the application itself. While Claire does not verbally interact with Gabe, she looks at him in the ways that the teacher prompts her to think about Gabe's favorite color.

When Claire advances them to the next screen, I come back with a green block that they can use in their picture, attempting to lessen the burden of either child having to get up and interrupt their play (line 12). Again, including him in play, the teacher tells Gabe where to tap on the iPad to get to the camera and demonstrates by pointing (line 15). Gabe follows his guidance (line 16) and then grabs the green block from my hand (line 17), which the teacher helps him position in the camera view (line 18).

So that the children do not have to move, I reach around Claire and tap the shutter button for them (line 19), and the teacher gives positive reinforcement (line 21). Claire moves stickers onto both her and Gabe's faces (line 22), blocking her own eye but not blocking Gabe's face (see decorated picture in Figure 5-8). Both the teacher and Claire laugh (lines 23-24), and Claire looks at Gabe (line 24). Including Gabe into the interactions, the teacher acknowledges what makes the sticker placement on Gabe's head funny and physically demonstrates where it is on Gabe's head (line 25). Claire then points to her own picture to acknowledge why her picture is funny as well (line 26).

- 1 Incloudle: What are your favorite colors? Tell each other!
- 2 Claire: ((Looking at Teacher.)) My favorite color is rainbow.
- 3 Teacher: Rainbow! Hmm.. I wonder what Gabe's favorite color is?
- 4 Claire: ((Looks at Gabe. Looks back at teacher.))
- 5 Teacher: Sometimes we can tell by what people wear.
- 6 Claire: ((Looks at what Gabe is wearing. Looks back at teacher.))
- 7 Teacher: The colors they wear. What do you think? What would be your guess... for Gabe?
- 8 Claire: ((Looks at Gabe and back at teacher.))
- 9 Teacher: I wonder what Gabe's favorite color is. ((To Gabe)) It looks like you like purple, Gabe. It looks like... he wears blue jackets all the time. Maybe blue.
- 10 Claire: ((Taps next button.))
- 11 Incloudle: Take a picture of yourselves with something that is my favorite color, green!
- 12 Kiley: ((Holds a green circular block between Claire and Gabe.))
- 13 Claire: ((Looks at the block.))
- 14 Gabe: ((Leans forward, toward the screen.))
- 15 Teacher: ((Pointing at the arrow button.)) () right there, and press the arrow.



Transcript 7 (continues on next page).








16	Gabe:	((Presses screen once but misses the arrow. Taps the arrow.))	
17	Gabe:	((Looks at the green block and takes it from Kiley's hand.))	
18	Teacher:	You can hold it up like this. ((Positions and holds up Gabe's hand that is holding the block.))	
19	Kiley:	((Reaches around Claire and presses the shutter button.))	
20	Incloudle:	((Makes camera sound. Takes picture.))	
21	Teacher:	Nice, Gabe.	
22	Claire:	((Moves stickers onto both her and Gabe's faces.))	
23	Teacher:	((Laughs.))	
24	Claire:	((Laughs and looks at Gabe.))	
25	Teacher:	((Points at Gabe's face in the picture.)) That's funny. It's on your head. ((Puts his hand toward Gabe's head, to mimic where the fox sticker is on Gabe's picture.))	
26	Claire:	And look it mine. I have a diamond. ((Points at her face in the picture.))	
Transcript 7, continued.			



Figure 5-8. Picture taken and decorated in Transcript 7.

Throughout this sequence, Gabe's inclusion into play with Includle would not have been possible without their teacher being involved. Includle could have been and still could be more accessible for non-verbal children by allowing them to answer questions physically instead of verbally (e.g., through tapping specific options on the screen; although this may have other accessibility effects). However, the supports that the teacher gave Gabe – bringing him into the conversation, prompting his actions onto the screen, physically supporting him during picture taking, and involving him in the picture reflection ensured that Gabe's participation was inclusive and equitable under the circumstances. At the same time, Claire physically included Gabe in the play, along with the support of the teacher. Although not verbally directing her responses at Gabe, she took turns pressing buttons, took up equal space in the picture, and decorated both of their faces, without covering his face, despite her covering her own.



























For the second situation of adult support, we can see subtle examples in a play event with Tristan, Howie, and me (Transcript 8). Here, the boys collaboratively play and communicate with each other mainly through non-verbal language while also engaging with Includle; they mimick each other's faces during picture taking and smile, look at each other, laugh, and point at their pictures afterward. Yet, there are points in their play where they need slightly more support in engaging with one another verbally or in taking turns. In one of these instances, I intervene to ensure that their communicative language and behaviors are directed at and recognized by one another, something that Includle does not do. However, in a second instance, I miss an opportunity to intervene to enable Howie to engage with Includle in the same way that Tristan is.

At the start of Transcript 8, Includle's character Barika relays an anecdote about her favorite number (line 1) and Howie tries to engage with Tristan nonverbally by turning and looking at him after smiling and laughing (line 2). Tristan does not acknowledge Howie's nonverbal bid for attention and goes onto the next screen (lines 2-4). Once Barika prompts the boys to tell each other their favorite numbers (line 5), Howie turns to look at Tristan, positioning himself for a conversation (line 6). However, Tristan instead turns away from Howie, toward me (offscreen, watching them) to give his answer, and then orients himself back to the

iPad to go to the next screen without interacting with Howie (line 7-8). I notice this and verbally interject by responding to Tristan that he should tell Howie his answer (line 9). This stops Tristan from moving onto the next screen, and he orients his face and gaze to Howie (lines 10-11). Enthusiastically, Howie answers the question, raising his hands above his head while he says his favorite number (line 12).

Even though my comment was to have Tristan actually speak *to* Howie, not to me, Tristan takes this an opportunity to listen to Howie, who in many other play events does not engage with Includle nor his play partners (e.g., Transcript 6). In this way, my intervention and Tristan's subsequent actions enable Howie to have a voice, when his typical behavior is not to speak or interject without verbal or nonverbal indication that it is okay to do so first.

Following this verbal exchange, the boys easily collaborate during picture taking through more physical communication—being in close proximity to one another (line 20), making similar faces (lines 18-19), and pointing and laughing at their picture (lines 21-22). However, when they both reach out simultaneously to move stickers onto their picture (lines 23-24), Tristan again dominates the interactions with Includle not only by saying “no” to Howie trying to decorate the picture (line 25) but also by grabbing Howie's wrist and moving Howie's hand down to the table (line 25). Tristan holds Howie's hand down for the entire time that he moves *both* of the stickers onto their faces in the picture (lines 25-28). Off to the side, I fail to notice this interaction; I do not intervene to let Howie have a turn in putting a sticker on the picture or to ensure Howie has any say in how his own face is decorated in the picture. Still, the boys look at each other and laugh at the decorated picture (line 27-28), and Howie moves his hand away from Tristan, who subsequently lets go (line 28).

1	Incloodle: ((Tristan and Howie look at the screen.)) I'm working on counting numbers up to one hundred.		
2	Howie: ((Laughs)) ((Smiling, turns and looks at Tristan, who is still looking at the screen. Looks away.))		
3	Incloodle: ((Both boys looking at the screen.)) My favorite number is ten.		
4	Tristan: ((Taps the next button.))		
5	Incloodle: What are your favorite numbers? Tell each other!		
6	Howie: ((Turns to look at Tristan.))		
7	Tristan: ((While Howie looks at him.)) Um. ((Turns and looks away from Howie, toward Kiley)) My favorite number is two thousand.		
8	Tristan: [((Looks back at the screen, goes to press the next button.]		
9	Kiley: ((Sitting off-camera, watching the boys play.)) [Cool. You can tell each other.]		
10	Tristan: ((Pulls his finger away from the screen.))		
11	Tristan: ((Turns to look at Howie. Slightly smiling.))		
12	Howie: ((Looking at Tristan.)) My favorite number is 8. ((Raises arms above head and smiles.))		
13	Tristan: ((Looks back toward the screen, and presses the next button.))		

Transcript 8 (continues on next page).

14 Howie: ((Puts arms back down and looks back to screen.))

15 Incloudle: Thanks for sharing! Take a picture of yourselves with [a number.]



16 Tristan: (((Looks at Howie, looks back at the screen.))]

17 Tristan: ((Taps the next button.))



18 Tristan: (((Makes face, showing teeth.))]



19 Howie: (((Makes face, opening mouth.)))

20 Tristan: ((Moves body toward Howie.)) ((Presses shutter button.))



21 Howie (((Laughs and points at picture.)))



22 Tristan: (((Laughs and points at picture.)))

23 Howie: (((Moves finger to screen, to move sticker.)))



24 Tristan: (((Moves finger to screen, to move sticker.)))

25 Tristan: No. ((Referring to Howie trying to move a sticker.)) ((Grabs Howie's wrist.))



26 Tristan: ((Holds Howie's wrist to the table while moves both stickers.))



27 Tristan: (((Laughing, looks at Howie. Still holding Howie's wrist on the table.))]



28 Howie: (((Laughing, looks at Tristan.))) ((Moves backward, away from Tristan, and Tristan releases his hold from Howie's hand.))



Transcript 8, continued.

These two instances within the same interaction sequence give evidence of how a small interjection can make more likely that a child is being included or participating in play equitably. While Tristan, the more dominant play partner, easily takes control over picture decorating when I am not paying attention, a small comment from me about talking to Howie prompts Tristan to turn and listen to Howie, who is overjoyed to give his answer in this context.

While Incloodle is purposefully open-ended to allow for flexible adaptation to the needs of different children, there is less technology enforcement in interacting with the application. There is no voice recognition to ensure both children are speaking or touch enforcement to make sure both children are getting a turn to tap the screen. In turn, children who need extra support—whether that be in the form of adults enforcing turn-taking or giving additional prompting and oversight to communicate (verbally or nonverbally)—often cannot co-engage with each other and Incloodle without an adult involved.

5.3.5 *Printing & Printed Pictures*

With the design iteration of Incloodle from 1.0 to 2.0, I added the ability for children to print pictures, with the intention for this to reward or reinforce children playing together (see Figure 5-3). The goal was for the printing experience and materiality of printed pictures to be meaningful to children; having printed pictures would be a physical emblem of their experience, beyond the pictures within Incloodle that do not “live” outside of the device and cannot be shared or taken home. Children’s collaborative interactions with the printer and with the physical pictures that they received after playing with Incloodle provided evidence that this goal was met. However, at the same time, agreeing on one picture to print was not as simple for children as I intended.

A long interaction sequence between Alex and Zoe shows the significance of both the printing experience and the physical pictures to children (Transcript 9). After Alex and Zoe both immediately agree on the same picture to print, I show them the printer and tell them the picture they chose will come out of it. Alex asks me if “kids get to keep [the picture],” and I tell him yes (lines 1-2). He tells his playmate Zoe this and

asks her if she wants to keep hers, to which she responds affirmatively (lines 4-5). Here is the first indication of the significance of the pictures as things that “kids get to keep.”

Then, I explain to the children how the printer is going to print two copies of their picture so they can each have one (lines 5-8) and start to describe how the printer works (lines 9-15). Eagerly, Alex asks Zoe if she is ready for the picture to come out and moves his head down to the printer, telling Zoe to do so as well multiple times, so she can “see it better” (lines 16-26). As the picture starts to come out of the printer, the children lift their heads in anticipation, giggling and squealing – “Look it’s right there!” says Alex (lines 28-32). Once the picture comes out of the printer, both children look at it, smiling and laughing (lines 34-35, 39). Then, the same interactions the children had previously around the printer and with each other continue while the second picture prints. They look up and down at and into the printer, and Alex excitedly and loudly tells Zoe he can see the second picture coming out of the printer (lines 39-45). Through these interactions, we see evidence of the value of the physical picture, as something the children expectantly wait for and orient to.

Once Zoe gets the second picture from the printer (lines 46-53), Alex and Zoe hold their pictures up next to each other, smiling and looking at them side-by-side (line 55). In this instance, the children’s joint attentive gaze at their pictures shows how the picture is not only meaningful to the children but something that they can hold and reflect on directly. Now that the children are done playing, Zoe walks away from the play area and Alex keenly runs toward his classmates at the back of the room to show them his picture (“Look!”) (lines 57-58). Alex calls over Zoe to show another classmate her picture too and then tells one classmate, “Look what we got!” (line 58). Again, the picture holds meaning to the children, as something they can share and show off to their friends in the class.

- 1 Alex: Do kids get to keep it?! ((Referring to the printed picture.))
- 2 Kiley: Yeah!
- 3 Alex: ((To Zoe)) It'll come out of there, Zoe. Kids get to keep it. Do you want to keep yours?
- 4 Zoe: Yeah.
- 5 Alex: Hey, that one's mine, right?
- 6 Kiley: Yeah, you're going to get TWO! So let's see.
- 7 Alex: Two?
- 8 Kiley: There'll be two. One for each of you. (1.0) Alriiight, let's see-
- 9 Alex: Like, one will come out of there and one will come out of there? ((Leaning forward, pointing to different parts of the printer.))
- 10 Kiley: They'll both come out of here. Let's wait.
- 11 Alex: Then what's that one for?
- 12 Kiley: This one-(2.0) I'll show you. (2.0) It's kind of slow. It's kind of loud, but it will go.
- 13 Zoe: It's not loud to ME.
- 14 Alex: ((Looks at Zoe and back to the printer.))
- 15 Kiley: You can hear it, right?
- 16 Alex: ((Looking at Zoe.)) Watch, it'll come out. Are you ready, Zoe? ((Leans head down toward printer and back up.))
- 17 Kiley: Right here, but we gotta wait, we can't pull it.
- 18 Alex: ((To Zoe) Put your head down here, k? ((Moves head down to look into the printer slot.))
- 19 Zoe: ((Moves head down.))
- 20 Alex: Down. ((Looks up and Zoe and back to printer.))
- 21 Zoe: ((Moves head back up, and moves tablet stand out of the way. Puts her head back down toward the printer.))
- 22 Alex: ((Looks at Zoe and back to printer.)) Taking slow. () putting your head down.
- 23 Zoe: ((Brings head back up and rests her chin in her hand.))
- 24 Alex: Lay down, Zoe, like this.
- 25 Zoe: ((Smiles, brings head down.))
- 26 Alex: So you can see it better.
- 27 Kiley: ((Gasps.))
- 28 Alex: ((Both children bring their heads back up.)) Look! It's right there!
- 29 Kiley: Don't pull it yet, I'll show you what you do with this part.
- 30 Alex: Why you gotta () and it comes out. (4.0)
- 31 Zoe: ((Giggles.))
- 32 Alex: ((Squeals, giggling. Looks at Zoe.))



- 33 Kiley: So now, what you do is with this, instead of pulling it, you--((both children lean down toward the printer))--put your finger ACROSS that, like this ((demonstrating while both children watch)). And when that happens ((printer cut noise heard)), it CUTS it. ((Printer releases picture.))
- 34 Alex: ((Holding picture in front of him, leans slightly toward Zoe, looking at the picture.)) ((Giggles))
- 35 Zoe: ((Looking at picture, smiling.))
- 36 Kiley: There's ONE! And it's a STICKER if you want to take it off.
- 37 Alex: ((Removing sticker.))
- 38 Kiley: And now it's going to print another one.
- 39 Alex: It's a sticker, Zoe! ((Both children smiling at the picture.)) Lay your head down so you can see. ((Lays head down.))
- 40 Zoe: ((Lays head down.)) (4.0)
- 41 Kiley: It's a SLOW printer.
- 42 Zoe: ((Distracted by something noisy behind her, looks up and away from printer.))
- 43 Kiley: It's coming!
- 44 Alex: ((Excitedly, squealing, tapping Zoey.)) I CAN SEE IT, ZOE! ((Giggles. Looks back down at printer.))
- 45 Zoe: ((Turns and smiles. Looking at printer now.)) (5.0)
- 46 Kiley: Pretty cool, right? Alright now, Zoe, you get to--instead of pulling it...
- 47 Zoe: ((Brings her hand toward the printer.))
- 48 Kiley: Yeah.
- 49 Zoe: ((Takes her hand away.))
- 50 Kiley: You can do it, Zoe.
- 51 Zoe: ((She swipes her finger across the printer.))
- 52 Kiley: There you go. Let's see, did it cut it? ((Printer cut sound heard.)) Now you can take it.
- 53 Zoe: ((Takes the picture.))
- 54 Kiley: There you gooo!
- 55 Alex: ((Giggling, lifts up his picture next to Zoe's.)) ((Both children looking at their pictures.))
- 56 Kiley: Pretty cool, right? Thanks for playing! Did you have a fun time?
- 57 Zoe: ((Walks away.))
- 58 Alex: ((Runs away toward classmates, sitting at a table behind them.)) ((To children sitting at table.)) Look! ((To Zoe, who come to the table)) Come show Faith! ((To Faith)) Look at what we got!



Transcript 9, continued.

Dylan and Geoff have a similar experience to Zoe and Alex when waiting for their pictures to print and reflecting on them (Transcript 11); however, their experience agreeing on a picture to print was not as seamless (

Transcript 10). Here, I will describe these interactions chronologically from picture selection to printing.

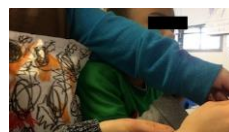
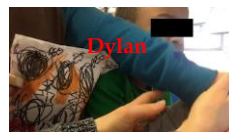
In

Transcript 10⁴, Dylan and Geoff are prompted to pick the picture that they both want to print. Dylan points to one picture he wants to print, which has “BOTH” of them in it (line 2, line 6). However, Geoff disagrees with Dylan on printing that picture (lines 7-13). Instead, he points to a picture that has more of his body/face in it compared to Dylan, which Dylan notices (“But that only has mostly you in it.”) (line 15). Geoff responds that he does not care (line 16), and Dylan offers his original picture as an option that includes both of them equally in the picture (lines 17-19).

Rather than attempting to make the children cooperate and come to a shared decision about one picture to print, I tell them that I will print them two copies of *both* pictures (line 20). Geoff nods to say he is okay with this decision (line 21), and Dylan excitedly exclaims, “Two of that and two of that!” while pointing at the pictures (line 22). In this interaction sequence, the picture selection process reveals a tension; the pictures hold meaning to children as something they want, yet they want different pictures for different reasons. In line with the goals of Incloudle, Dylan wants a picture that physically includes both of them in it. Yet, Geoff wants a picture that features more of him in it as opposed to his play partner. While getting a printed picture that they want is important, the fact that the children cannot agree upon one picture and that Geoff’s choice is not inclusive of Dylan reveals a conflict in what Incloudle intends (to promote inclusion) and what a child might want.

⁴ It is important to note that I consistently intervene in this interaction sequence so neither child touches the screen. This is because, at this point of the design of Incloudle 2.0, there was no way to go back and change the selected picture to print. Therefore, I attempted to mediate children’s selection of pictures such that one child would not tap on a picture immediately without input from their play partner. If this happened, I would have to exit out of Incloudle and let children print from the iOS photos app instead.

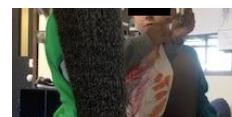
- 1 Incloodle: Which picture do [you both like the best?]
- 2 Dylan: [Let's do that one. ((Reaching his arm over to point.))]
- 3 Kiley: [((Holding Dylan's hand so he doesn't tap the screen without Geoff's input.))] ((Lets go.))
- 4 Geoff: No-oh.
- 5 Kiley: Okay, waitwaitwaitwait. ((Holds Geoff's hand back from touching the screen.)) Before touching it, which one do you think?
- 6 Dylan: This one! ((Pointing at the screen.)) It has all-BOTH of us.
- 7 Kiley: You like that one?
- 8 Dylan: That one.
- 9 Geoff: No.
- 10 Kiley: Which one do you like, Geoff?
- 11 Geoff: ((Looking at screen, starting to point)) Hmm..
- 12 Kiley: Without touching it. ((Holding hand up to block screen.))
- 13 Geoff: I like the one ((pointing))-I like that ((pointing)) one.
- 14 Kiley: You like that one-
- 15 Dylan: ((Jumping up and down.)) But that only has, mostly you in it.
- 16 Geoff: I don't care.
- 17 Dylan: ((Pointing)) This one has that-
- 18 Kiley: That one has both of you?
- 19 Dylan: Yeah! (1.0)
- 20 Kiley: Does that make sense, Geoff? Do you want that one ((referring to the picture with both of them in it)) also? Can we do two of this ((picture with both children)) and you also get that one ((referring to the picture Geoff wants))?
- 21 Geoff: ((Nods in affirmation.))
- 22 Dylan: Two of that ((points to picture)) and two of that ((points to picture))!
- 23 Kiley: Okay.



A subsequent interaction sequence with Geoff and Dylan further shows the worth that the pictures have for both children, which they recognize as a shared yet distinct interest (Transcript 11). After I exit out of Includle to print copies of the two pictures, I ask them if they are done playing and Geoff says he wants “ours to print, both of ours” (lines 1-2), recognizing the importance of the pictures *and* how they want different pictures. The boys run over to the printer to see their pictures print, with Geoff exclaiming, “I got one! I got one!” (lines 4-5). Once Geoff gets the picture, he cheers, “YES!” but questions why the picture is not the one he chose (lines 7, 9, 11). When I let him know that that one will come out later, he rejoices (“YAY!”) (lines 12-13). At the same time, Dylan asks where his picture is (line 8). When another picture starts to print, he celebrates (“Mine’s coming!”) and looks down into the printer, similar to how Zoe and Alex did (line 14). As soon as he gets the picture, he yells (“Ah!”) while looking at it (line 16). He jumps up and down excitedly, explaining that the picture he has will be for him and his stuffed animal (i.e., stuffie) and physically holds the picture over the stuffed animal (line 18). As his speech and interaction with the picture and stuffie show, the picture becomes something he can keep and share with other objects that are meaningful to him.

After, Geoff says that he gets the next picture and Dylan responds to say he gets the “OTHER next one” (lines 19-20). Here, the boys are simultaneously interested in getting and keeping their pictures; however, for Geoff, this is more about receiving the picture that he specifically wanted, contrasting Dylan, who is excited to both have pictures.

- 1 Kiley: Do you want to do more, or are you done?
- 2 Geoff: I want ours to print, both of ours.
- 3 Kiley: ((Pointing to the printer.)) Do you want to watch it for (·) the printing?
- 4 Dylan: [Oh, yes, printing!]((Moves around chair to the printer.))
- 5 Geoff: [((Turns to the printer.))] I got one, I got one! ((Moves his finger over the printer to cut the picture.))
- 6 Kiley: ((Comes over to the printer.)) Ooo, yeah, exactly! That's what you want to do ((referring to swiping to cut the picture)). ((Swipes finger again. Printer cuts the picture.)) There you go.
- 7 Geoff: ((Picks up the picture and looks at it.))
- 8 Dylan: Hey, where's mine? () don't have one!
- 9 Geoff: ((Slightly jumping, holding and looking at picture.)) YES!
- 10 Kiley: It has both your faces in there, right?!
- 11 Geoff: Hey, this one didn't come with the letters ((pointing at picture.))
- 12 Kiley: The next one's gonna have letters. Actually, there's gonna be one more of this one and then the letter one.
- 13 Geoff: YAY!
- 14 Dylan: Mine's coming! ((Leaning head down to look in printer.))
- 15 Kiley: ((Both boys look at the printer while it prints.)) Can you do the thing across the top? ((Both boys swipe their fingers.)) Yeah, there you go, yeah!
- 16 Dylan: ((Takes the picture. Looking at it.)) Ah!
- 17 Kiley: Okay, now two more are going to come out.
- 18 Dylan: ((Jumping up and down slightly.)) () Two! ((Jumping up and down.)) ((Holds the picture onto his paper stuffed "animal.") This one's for my stuffie and me! ((Looks down at printer.)) Coming out!
- 19 Geoff: I get the next one.
- 20 Dylan: And then I'll get the OTHER next one!



Transcript 11.

In the cases of Zoe/Alex and Dylan/Geoff, we see the printer and pictures as motivating. The printing experiences and the pictures are central to their interactions, both speech and movement, portraying anticipation and excitement. The children are also enthusiastic by the prospect of keeping and sharing their photos. Alex runs and shows his picture to Faith, calling Zoe along, while Dylan exclaims how his picture is going to be for him and the stuffed animal he made. Nevertheless, while Zoe's and Alex's interactions around pictures and printing involved one picture they both easily chose, the picture selection experience for Dylan and Geoff was not as easy. While they were jointly attending to the printer and pictures, Geoff's interest in having a separate picture from Dylan shows how the picture itself does not necessarily hold meaning around inclusion and cooperation for children in the way that I embedded it into Incloudle.

5.3.6 *Pictures as "Proof" of Inclusion vs. the "Work" of Inclusion Behind the Picture*

Analysis of the pictures saved to Incloudle's camera roll in conjunction with the collected video data revealed another tension between what was captured by Incloudle—a frozen moment of interaction in the play event—and what was captured via video recording—the interactions actually involved in that play event. Figure 5-9 with Transcript 12 and Figure 5-10 with Transcript 13 present two narratives in which the picture could become proof of inclusion (or exclusion) during play with Incloudle, despite the actual interactions that occurred to achieve the picture.

In Transcript 12, while not fully visible in the recording, I can be heard off-camera, as I notice Russell leaning in, covering the lens, and blocking Zoe from being seen in the picture. I quickly intervene, disrupting their play by pulling the iPad off the stand, causing Russell to pull back his face and reorient himself further away from the iPad. I put the iPad back down, pushing it and the stand further back on the table, widening the angle of view of the lens to include both Zoe and Russell's bodies and faces. The ensuing picture they take is shown in Figure 5-9. However, this image alone, a picture that can be printed, shown to others in the classroom, and taken home to the children's families, is at odds with the work of inclusion that happened "behind" it. While I structured the picture by moving the iPad, I remain almost entirely invisible in the "proof" of participation, engagement, and inclusion that Incloudle produces.

As this dynamic (of Russell getting too close to the screen and excluding Zoe from being in the actual picture) continued to occur, I turned on technology enforcement. However, this did not stop him from putting his face too close to the camera. Rather, it just prevented him from taking the picture when his face was in that position. In these situations, I still had to intervene and remind Russell that it would not take the picture unless he backed up and included both his and Zoe's face in the camera.














		
<p>Kiley: Hey, hey, hey! Here, let's do something.</p>	<p>Kiley: I have an idea. ((Picks up the iPad.))</p>	<p>Kiley: ((Puts the iPad back down, further away.)) Let's push it back a little bit, so both your faces are in it.</p>
<p>Transcript 12.</p>		



Figure 5-9. Picture taken after interaction sequence in Transcript 12.

Similarly, in Transcript 13, Includle's character Nikki prompts the children to take a picture together making cheerful faces (line 1). Zoe and David take turns pressing the buttons (Zoe, line 2 and David, line 6). David counts to three to take the picture together (lines 5-6) while Zoe smiles (line 4). This co-engagement is joyful, involving laughs and smiles, and coordination of body positioning and virtual space in the picture. Yet, when the resulting picture (Figure 5-10) is shown onscreen, I call David "silly" for not being "in" the picture (line 8). This interaction sequence parallels other instances in which teachers in the classroom had me reprint pictures (including for David) when a picture may not have included a face in it

(even if it was the child’s decision). In fact, David often only engaged with Incloudle during the picture-taking portions of the design, running away during the character and verbal discussion portions of the application and then joyously returning to take pictures, counting to three and pressing the shutter button, often not caring if his face was in the picture or not. In this way, Incloudle supported David in equitable, intermittent yet fluid participation with the application and his peers, but this type of engagement was not consistently recognized as being collaborative *enough* for adults, including myself, in the moment.

1	Incloudle:	Thanks for sharing! Take a picture of yourselves making cheerful faces!	
2	Zoe:	((Reaches to screen to press the next button.))	
3	David:	((Laughs and moves his body backward.))	
4	Zoe:	[((Smiles))]	
5	David:	[((Begins count to take the picture.)) One.]	
6	David:	((Reaches forward to tap the shutter button.)) Two, three. ((Presses shutter button.))	
7	Incloudle:	((Camera makes sound. Takes picture.))	
8	Kiley:	Hey! ((Taps David’s back. To David)) You weren’t in that picture, siilly.	
			
			
			

Transcript 13.



Figure 5-10. Picture taken after interaction sequence in Transcript 13.

5.4 DISCUSSION

Incloodle—a technology that mediates co-participation and collaborative engagement—works within a complex system of (inter)action with socio-material resources. This system complicates what it “means” to be inclusive, depending on those involved (including their abilities and needs), the adult facilitators (when they intervene and what they “count” as inclusive), and what the technology itself engenders/restricts based on what may be more normative, exogenous notions of ‘cooperation’ and ‘inclusion’ embedded in that interactive object.

Through my analytic process, I found Incloodle provided semiotic structure for reflecting on social and emotional topics and for picture-taking activities among the children, whether that be with objects or by making certain faces. The children made connections to their own experiences and the experiences of their classmates, as they related to the characters in the application and the social-emotional topics they presented. They also interpreted directives for picture-taking as necessary or unnecessary by using them to make arguments for what should (or should not) occur in a picture in verbal or embodied ways.

Likewise, Incloodle structured children’s participation as they negotiated their physical space to match the structure of Incloodle’s digital space. This was true even in the contrasting cases of Lisa/Adam and Sam/Howie, in which the more dominant drivers of the interactions (Lisa and Sam) approached this shifting of space very differently. However, the ways that these more dominant interactants positioned and moved themselves, their play partner, and the iPad showed the potential for the lens to assemble how children make sense of what counts as engagement (or individual participation) vs. co-engagement (or inclusion or cooperative participation).

Analyses of children’s interactions with each other and Incloodle revealed the teachers and I, as adults, became integral to the Incloodle system as additional mediators of children’s collaborative participation in this socio-material context. We contextualized and scaffolded children’s play, especially by ensuring that neurodivergent children were included in engagements with Incloodle. Like in the case of Gabe and Claire,

this involved providing further supports for the neurodivergent child to physically interact with the tablet and making sure that the neurodivergent child was involved in social-emotional conversation and picture reflection. Akin to the case of Howie and Tristan, this also involved interjecting to remind neurotypical children to interact and cooperate with their neurodivergent play partners.

Finally, children's interactions with and around the printer and their printed pictures showed the significance of printing to children, not only as reinforcing for their experience (as a "reward" that they received after playing together) but also as a material artifact that they could share with each other, take home, and otherwise reflect on. Children gathered around the printer, reflecting on how it was working and negotiating how they were going to get those pictures. Children also chose pictures to print that included all of their faces, showing them to other teachers and students while exclaiming that they are all in the picture. Simultaneously, picking which picture to print was not always easy for the children, as they often disagreed on which picture they wanted to both have copies of.

At the same time, analysis of the resultant pictures of Incloodle problematized the notion of how inclusion was embedded in Incloodle (by me). Therefore, it is significant to think about how I both designed Incloodle and structured co-play with Incloodle—particularly around the picture-taking experiences of the application—as aligning with more exogenous notions of what "counts" as inclusive participation (i.e., Stevens, 2010). By focusing on the end result (the picture) as proof of inclusive participation, I excluded *the interactions themselves* as having meaning, which may not have always aligned with having a face in a picture. Rather, this presentation of a moment could and did easily become a misrepresentation of children's equitable engagement and, potentially, endogenous notions of what equitable participation and inclusion could entail for and mean to children, particularly those with different abilities and needs.

Similar to how video recording is itself theory (Hall, 2000), Incloodle's pictures change what others may or can interpret from those pictures. Even more, like how "[a] recording first and a transcript later should not be presented or seen as attempt to reproduce the entire original experience" (Duranti, 2006, p. 308), pictures

with Includle cannot be seen as the entire original experience; they are only a particular slice *of a particular slice of the universe* in which I am interested. However, these pictures live on, beyond the boundaries of my work, with the children both in the classroom and outside of it, as a new semiotic resource for their friends, teachers, and families. More work needs to be done to understand the wider implications of these types of pictures, which standing alone may do work of inclusion for those that are in them and view them.

5.5 SUMMARY OF CONTRIBUTION

Ultimately, Includle became an important actor within the socio-material context of inclusive play, shaping what it “means” to be inclusive from the perspectives of children, adults, and the technology itself. When Includle provided prompts and structure for discussion and picture-taking, children used this as a basis to interact with each other, connect with their playmates and classmates, and negotiate their positioning in the real world to match what was seen in virtual space, including both themselves and their playmates in pictures. This was not always easy for children to do on their own with the application; and, therefore, the teachers and I often stepped in to facilitate inclusion in relation to the application, making sure engagement with and around it was equitable for both playmates. Finally, Includle itself embedded notions of inclusion within its design by telling children to converse with each other and take pictures together. Utilizing the camera and printer provided material reinforcement for collaboration and cooperation, as children constructed and then later printed an image of themselves together. In many cases, their photography resulted in ‘inclusive’ pictures in which the children were “seen” as meaningfully participating by both being in the picture. Yet, the picture sometimes did not match children’s intentions and interactions behind it – whether that be (1) due to my own enforcement or face detection’s enforcement of inclusion during picture taking or (2) due to children not wanting to be “in” the picture (e.g., by covering their faces or moving outside the lens).

Through this analysis of illustrative interaction sequences as narrative cases, I contribute a generative, empirical understanding of how neurodiverse children jointly engage and play with technology in a

natural setting over an extended period of time. I argue Includle—a technology designed for inclusive play—acts as a coordinative artefact for equitable participation and engagement, and social-emotional learning as a member’s phenomenon (Stevens, 2010). By interacting through and around Includle with adult support, children had opportunities to learn about and connect to each other socially. In this way, the interactions that emerged were evidence of children’s joint learning of how to be inclusive spatially, in verbal and nonverbal communication, and in engagement with, around, and through the device.

Chapter 6. DISCUSSION

Across the studies in this dissertation, I investigated how to design technologies for inclusive play between neurodiverse children. I employed an integrative approach to this research, utilizing ethnographic, design, experimental, and field study methods from HCI and the learning sciences. My work also followed a human-centered design process. Initially, I gained a formative understanding of the design space by investigating the current state of inclusive play from the perspectives of children, parents, and teachers and by utilizing literature in early childhood special and inclusive education. I designed an initial prototype that drew on the design considerations I formulated from this foundational study. This prototype, Incloodle 1.0, allowed me to test the feasibility of specific design features to facilitate inclusive play between neurodiverse children in the short-term within a controlled lab environment. After this laboratory study, I iterated on the design of Incloodle to build a more fully functional prototype, Incloodle 2.0. I used this updated prototype as an intervention in the more natural context of an inclusive kindergarten class over a longer period of time; this allowed me to investigate children's interactions with each other, with adults, and with Incloodle.

Through this work, I aimed to change how the field of HCI thinks about both collaborative and accessible technology design, expanding these notions to consider inclusion as continual reflection on equity and meaningful co-participation. My initial study led to a list of facilitators and barriers that designers could harness in designing for inclusive play among neurodiverse children, by harnessing the facilitators and attempting to overcome the barriers. My lab study resulted in knowledge about the impact of specific design features on inclusive play; technology-enforced cooperation changed interactions between neurotypical and neurodivergent children when playing with Incloodle, being more effective in leading to cooperation for children who needed the extra support. However, for children who did not need this extra support, technology-enforcement was limiting to their creativity, and when Incloodle had tech-enforcement, playing was less fun on average for all children. Joint photography and button-tapping were

effective embedded supports for inclusive play, as children took turns, cooperated in who would hold objects in the pictures and who would press the shutter button, and mirrored each other's faces. Images also served as a point of reflection for children, who laughed, pointed at, and commented on their pictures. Yet, in this study, there was not enough evidence to show any positive impact of the characters or character-based prompting on children or their inclusive play experiences. By iterating on Includle, taking it into an inclusive kindergarten class over a 2.5-month period, and conducting a deep analysis of children's interactions with and around the application, I found that children connected and reflected on their experiences in relation to the characters and discussion prompts. Children also made meaning of the "rules" of Includle, either following its structure in an embodied way, not following its structure, or physically and/or verbally deliberating on how to engage with its structure together. Similarly, children negotiated their physical and virtual space by moving themselves, their play partners, and/or the tablet to include or exclude children from being in the picture. Through this study, it also became clear that adults were tied to the design and use of Includle as scaffolds for children's play. Additionally, printing and physically receiving pictures were motivating and reinforcing for inclusive play. However, these pictures became "proof" of inclusion or exclusion, which may or may not have matched the inclusive/equitable or exclusive/inequitable interactions that occurred behind the picture, posing a question of what a picture's role is in inclusion, beyond the moments of interaction.

Reflecting on this research and design work, in the following section, I discuss specific design features and their ability to support children during inclusive play. Then I introduce the concept of inclusive joint media engagement, as something that can draw on my inclusive play technology research and offer insights into a future research and design agenda based on my design work and studies. Finally, I summarize the contributions I offer in this dissertation, discuss areas of future work, and make summative, concluding remarks.

6.1 DESIGNING FOR INCLUSIVE PLAY AMONG NEURODIVERSE CHILDREN

Includle is a semi-structured application for collaborative play that is intended to allow for adjustability, adaptation, and individualization based on the children whom are playing with it. Includle embeds an understanding of the design space of inclusive play from the perspectives of children, parents, and teacher, and specifically works to address all of the considerations that I offer as being important in designing for inclusive play (Chapter 3). In relation to inclusive play with technology, I argue that adults in this context can be just as important as the technology itself to scaffold and contextualize interactions among children. In the subsections that follow, based on the findings of my dissertation studies, I review the ways in which specific design features can be utilized in other technologies for inclusive play among neurodiverse children.

6.1.1 *Photography & Printing Physical Pictures*

First, I argue that photography and printing physical pictures are something that the human-computer interaction community should focus on more when it relates to designing for collaborative play experiences between young neurodiverse children. Through the picture-taking process, technology offers embedded support for mirroring behaviors, which relates to feelings of closeness in friendship and peer modeling (Garfinkle & Schwartz, 2002; Rabinowitch & Knafo-Noam, 2015; Watkins et al., 2015). It also offers embedded support for cooperation in picture-taking, including shared negotiation of physical and virtual space, joint attention, and learning through embodied understandings of social and emotional learning topics. Decoration of pictures (discussed in my design of Includle 2.0, although not in-depth in my interaction analysis) allows for further cooperation and personalization of the pictures taken as well. However, I also contend that design paradigms of unlimited stickers or stamps that (as I observed in the classroom with other apps) can be distracting by leading to repetitive interactions that do not support progression or learning.

My longer-term intervention also showed that the materiality of pictures can be meaningful to neurodiverse children during play as well. Physical pictures are artifacts that they can keep as their own, unlike digital pictures on a screen or in the cloud. In this way, printing experiences and physical pictures are reinforcing and motivating for children's inclusive play and also allow them to reflect on their experiences and share a meaningful inclusive shared experience with other people, like their parents, teachers, and other friends. Thus, material pictures have the ability to live on as a frozen moment in time; although, it is possible that this frozen moment does not actually match the (equitable or inequitable, participatory or non-participatory, inclusive or exclusive) interactions behind it. There is more work to be done to understand the wider implications of this on adult and child perceptions, attitudes, and behaviors and their "rippling" effect (Casey, 2005b).

6.1.2 *Technology-Enforced Cooperation*

Although informed by related literature, how I designed technology-enforced cooperation for inclusive play was through an exogenous perspective. While I took into account the perspectives, attitudes, and experiences of parents, teachers, and children during my formative research, there was no specific investigation in this study into photography in particular. Rather, I used my design intuition and theoretical foundation to move forward in creating a photography-based experience for inclusive play. However, by utilizing face detection for cooperation during photography, I embedded an exogenous notion of what inclusion should be during engagement with Incloudle. Just because two children's faces are in a picture does not mean that the interactions behind that picture were, in fact, inclusive (although they could be, as well). And vice versa, having one or no faces in a picture does not necessarily mean that the interactions behind that picture were *not* inclusive. Due to this variability, it is important to not *prescribe* the ways that children can interact with technology through enforcement statically. Instead, like how I incorporated a toggle to turn on or off tech-enforcement for picture-taking, technology-enforcement in other contexts or designs should be dynamic or changeable by people.

Reflexively, I recognize that my own view of inclusion during picture taking was evident in how I personally scaffolded children's joint photography experiences by making sure that both children were physically in pictures or commenting that it was silly or that they needed to retake pictures when both of their faces were not in a picture. Based on my own experience, adults need to be cognizant of and reflexive about their role as scaffolders of children's joint inclusive experiences, paying attention to what is equitable participation and engagement depending on the children who are playing.

Moreover, while I designed a toggle for technology-enforcement into Incloodle based on the results of the laboratory study, this embedded support for collaboration or cooperation needs further contextualization to more thoughtfully facilitate inclusive play and learning. For example, as it stands now in Incloodle with technology-enforcement, children are required to put both of their faces into a picture without any reasoning or contextualization of why this is necessary. Unlike other embedded supports for cooperation, like providing two scissors to three children during an art activity or having children play with a wagon because it cannot be used alone, it is not clear why a picture can only be taken when two faces are in the camera frame. Either, direct supports are necessary to indicate why it is important to include our playmates in this context or there needs to be some other contextualizing factor that might require a reason to cooperate (e.g., two children need to be in a picture, smiling, so that they can show how many teeth they have all together). This may be the difference between having children change their pro-social behaviors vs. learn why it is important to share, compromise, and cooperate with other people in a contextualized way.

There are also many other types of cooperation that could be enforced by design that might lower barriers to inclusive play. For example, children's struggling with turn-taking and simultaneously touching the application screen demonstrated that this was a challenging aspect of co-engaging with Incloodle. As in the cases of SIDES (Piper et al., 2006), Zody (Boyd et al., 2015), the Collaborative Puzzle Game (Battocchi et al., 2009), and Untangle (Juan Pablo Hourcade et al., 2013), technology-enforcement for cooperative on-screen interactions via collaborative gestures or other mechanisms could be successful for neurodiverse

children. There is room for exploration to understand how different types of joint interactions might be mediated with dynamic enforcement *and* contextualization, especially on small device like a tablet. For instance, examining turn-taking with face recognition (i.e., to determine who is holding the device or taking up more interactional space physically) or joint audio recording (e.g., singing, answering questions) with speaker recognition (Kinnunen & Li, 2010) and how these different kinds of tech-enforcement affect inclusive play could be fruitful areas of future investigation. Additionally, more research could be done to examine neurodiverse children's co-located use of multiple small portable devices, similar to how researchers examined the co-located use of 7" tablets and mobile phones for learning by young students in classrooms in India (Jain et al., 2011; Sobel, Kovacs, et al., 2017).

6.1.3 *Character Narratives & Discussion Prompts*

Characters with stories, who prompt reflective, social-emotional topic-based conversations or interactions between neurodiverse children are also productive for inclusive play. These types of characters and discussion prompts offer more direct support for inclusion and social-emotional learning; transparency about disability and how we all have similarities and differences; and a focus on children's interests and strengths, with the goal of helping children get to know each other better, including their likes, dislikes, and needs. This makes sense as researchers have connected parasocial relationships, or meaningful one-sided relationships with characters (Horton & Richard Wohl, 1956), to fostering learning goals for children (Bond & Calvert, 2014; J. H. Gray, Reardon, & Kotler, 2017).

There also need to be ways to answer questions and engage in conversation about topics that do not come more easily to children, for example by building up social-emotional topics from simpler questions to more in-depth ones over time, according to children's zones of proximal development (Vygotsky, 1980). Additionally, technologies for inclusive play need to allow for non-verbal responses and interactions to ensure that children with speech impairments or disabilities/disorders that affect verbal communication can still equitably participate.

Over time, characters had more of an impact in my intervention with Incloudle compared to the lab study, as children got to know the application and each other better over the months they played together. These characters caused connections and reflections on their own and each other's experiences. Drawing on the vast amount of current children's media – e.g., television (Christensen & Myford, 2014; Gikow, 2009; Mares & Woodard, 2005), digital games ("Feelings Games," n.d.), books (Beech, 2012), and social stories (C. A. Gray & Garand, 1993) – that focus on social and emotional learning and/or disability awareness, technologies for inclusive play should continue to incorporate characters whose stories prompt learning about our similarities and differences, likes, dislikes, strengths, and needs.

Similarly, it is important to provide diverse representation and diverse experiences into children's technologies for inclusive play, such that children have media-based characters and stories to which they can personally relate and that show them the diversity of human experience. This is in line with evidence that meaningful media representation impacts children, like empowering them (vs. reinforcing stereotypes); validating their identities; giving them common ground for dialogues and understanding about diversity, prejudice, and/or unique, intersectional identity-based experiences; and allowing them to more effectively learn from the media (e.g., Anyiwo, Ward, Day Fletcher, & Rowley, 2018; Finkelstein, 2015; Finkelstein, Yarzebinski, Vaughn, Ogan, & Cassell, 2013; McNroy & Craig, 2017; Roper & Clifton, 2013; Thomas, 2016). Following this idea, recently Sesame Workshop, the nonprofit organization behind the television program *Sesame Street*, is spearheading a national initiative called "See Amazing in All Children," which aims to "combat the stigma and isolation" experienced by autistic children their families and to "help increase understanding, reduce stigma, and demonstrate the commonalities that children with [a]utism share with all children" ("See Amazing in All Children," n.d.). As part of this initiative, they have introduced Julia, a new Muppet with autism into their television program, and offer a range of videos for children and parents about Julia, autism, and how all children have needs and strengths. Similarly, a grassroots coalition called KIDMAP (Kids Inclusive and Diverse Media Action Project) is supporting "the creation of diverse and inclusive children's media" via research, design guidelines, and best practices to

help content developers (“KIDMAP,” n.d.). Following these examples, technology for inclusive play requires the incorporation of children with disabilities and with diverse strengths and needs into its content.

6.2 DESIGNING FOR INCLUSIVE JOINT MEDIA ENGAGEMENT

As I described in Chapter 2.3.3, Takeuchi and Stevens (2011) describe six conditions that lead to productive joint media engagement: (1) mutual engagement, (2) dialogic inquiry, (3) co-creation, (4) boundary crossing, (5) intention to develop, and (6) focus on content, not control. In the case of my dissertation work, I claim that Incloudle provided the conditions for (1)-(5). Children were motivated to participate, largely due to the picture-taking aspect of Incloudle (1-mutual engagement). They collaborated to make meaning in answering the questions and taking pictures (2-dialogic inquiry). Together, they built joint understandings of each other and of how to play with the application, while at the same time co-constructing photos (3-co-creation). Engagement with Incloudle allowed children to reflect on their past experiences and gave them pictures to reflect on in the future (4-boundary crossing). And, children were driven to continue to play, meeting characters, taking pictures, and “getting stars” until they could receive a picture (5-intention to develop). In terms of (6) focusing on content vs. control, joint interactions with Incloudle were more difficult for the children in my studies; while for some pairs/groups of children, turn-taking, cooperation during picture-taking, and picture selection came easily, this was not true for all children who played with Incloudle.

However, in examining these conditions in relation to Incloudle, I suggest that there is more to take into account for productive JME when co-participants are diverse in their physical, cognitive, behavioral, social, or emotional abilities and needs. I refer to this type of shared experiences with media among people with and without disabilities as **inclusive joint media engagement**.

Grounded in the investigations I discussed in this dissertation, I offer three more conditions for productive *inclusive JME* in particular. First, engagement must be **adaptable** or individualizable to be equitable and

inclusive. Often, this means that engagement should be relatively open-ended or that children have opportunities to make meaning out of their participation with media in ways that match their abilities and needs and not in ways that are narrowly imposed by the media's design. A related positive example of adapting engagement for inclusive, equitable participation is with the location-based mobile game *Pokémon GO*; with this application, different parents and children with diverse developmental needs and abilities were able to play the game together because of how the device could be shared during gameplay, despite it not being explicitly designed for collaborative use (Sobel, Bhattacharya, et al., 2017). Second, engagement should be **empowering, allowing children to demonstrate their strengths**. In conjunction with being motivated to engage and intending to grow through participation (i.e., original conditions for productive JME by Takeuchi and Stevens (2011)), when children with diverse abilities co-engage with new media, they should feel confident about their participation and be excited to contribute. Third, productive inclusive JME does not occur in a silo—it should **draw on a myriad of interactional resources**, including (but not limited to) adult support, assistive technologies, and other contextualizing and/or translational tools or scaffolding. Like how JME that allows for boundary crossing across time and space will be productive, inclusive JME that draws on many interactional resources in situ will ensure that children can connect with each other and with the media they are using. In turn, children can interact with and learn from each other both around and through a technological medium. Future research should examine (1) how different types of technologies may already support these three new conditions and (2) alternative ways to consider adaptability, empowerment, and other interactional resources in relation to co-engagement with technology for children with and without disabilities.

6.3 CONTRIBUTIONS

The first contribution of this work is an empirical, generative understanding of the current state of inclusive play, which I offered through both ethnographically-based research and design workshops with parents of neurodivergent and neurotypical children, inclusive education teachers, and neurodivergent and neurotypical children. This generative knowledge offered a design-oriented conceptualization of inclusive

play that designers could use by drawing on the facilitators of inclusive play and working to overcome the barriers when producing technologies in this space.

The second contribution of my dissertation is a lab-based evaluation of a collaborative technology for inclusive play. Before running a longer-term field study, this short-term evaluation provided insights into the feasibility of specific design features to support neurodiverse children with successful inclusive play. Through mixed-methods analysis of their play, I showed the effectiveness or ineffectiveness of basic technology-enforced cooperation, simple character-based prompting, and photography in supporting neurodiverse children in playing together.

Similarly, my third contribution is an empirical analysis of the interactions among neurodiverse children, adults, and Includle in the natural context of an inclusive kindergarten classroom over an extended period of time. This micro-analysis of child-to-child interactions, adult-to-child (and vice-versa) interactions, and child-to-technology (and vice-versa) interactions and participation structures allowed me to unpack the ways in which Includle was positioned as a mediational tool, structuring artifact, and semiotic resource in regard to inclusive, equitable, meaningful co-participation. My analytic work offers evidence of children's joint endogenous learning of how to be inclusive spatially, communicatively, and in interaction/engagement with, around, and through technology.

The fourth contribution of my dissertation is Includle as an artifact (Wobbrock & Kientz, 2016) that embeds values of inclusion and equity into its design and may compel new possible and preferable futures. I iteratively designed Includle along with the help of many researchers and designers, based on my foundational work, related literature, and lab study results. In this dissertation, I show two main iterations of Includle from an early to a more fully functional prototype.

The final fifth and sixth contributions of this work include generative theory around designing for inclusive play among neurodiverse children and for inclusive joint media engagement. I discuss how designers may incorporate photography, physical pictures, technology-enforcement for cooperation, and diverse

characters and character-based prompting into their technologies for inclusive play. Then, I introduce *inclusive joint media engagement* as a concept that can build on my technology for inclusive play research. Here, I expand on what we know leads to productive JME experiences by proposing three conditions as important for productive inclusive joint media engagement in particular.

With all of these contributions, I offer ways for designers and researchers to think about what it means to design technology for collaborative experiences among children with and without disabilities, expanding beyond typical paradigms of designing technology for collaboration or for children with disabilities.

6.4 FUTURE WORK

There are several areas of future work that build on the research I presented in this dissertation. Regarding inclusive play in particular, a clear next step is to study the long-term use of Includle in a classroom *without* my (or another researcher's) direct involvement. In this context, do teachers scaffold inclusive play and connect children's experiences with the application to their curriculum content? If so, how? If not, why?

Along the same lines, more work is needed to investigate how my design insights might apply differently to unique contexts (e.g., home vs. school; children who are strangers vs. who already know each other). Additionally, future research should examine how additional ethical issues might play a role in the design of technology for inclusive play as well. While my work points to stakeholders' values surrounding technology and play, future work can explore how values like privacy might introduce tradeoffs between, for example, the facilitators and barriers I presented when designing inclusive play technology.

There are also additional opportunities to study other technologies for collaborative, inclusive play. The technologies could include a wider diversity of design features to grasp their impacts on the interactions, learning, and inclusive behaviors and attitudes of children with and without disabilities (i.e., not just neurodivergent and neurotypical children) long-term in different contexts. Given the impact of positioning,

physicality, and materiality in my own studies, including children with physical and sensory impairments into future studies is particularly important.

Concerning inclusive joint media engagement, future work should study co-engagement of children with a wider range of disabilities (i.e., including physical and sensory impairments), with different age groups (i.e., younger and older children), within-generational experiences (i.e., between or among children with and without disabilities), intergenerational experiences (i.e., between or among children and adults, either of whom have disabilities), and with other technologies that are not necessarily play-based (e.g., co-viewing videos online, pair-programming in blocks-based coding environments, etc.).

Finally, future work in this area would benefit greatly from getting more direct input from children with and without disabilities in the design process. Within HCI, there has been a strong movement toward not only designing *for* neurodivergent children but also *with* them (e.g., Benton et al., 2014; Fails, 2012). In the same way, to better inform the design of technologies for inclusive engagement among children with diverse abilities and needs, we need children with and without disabilities to participate in design alongside adults. Participatory design with children usually involves children who are older than six because designing with younger children is not usually recommended (Fails, 2012). However, based on my experiences with children in the inclusive classroom, there is room for innovation on new methods that can support designing with younger and older children of diverse abilities and needs together, inclusively.

6.5 CONCLUSIONS

Early childhood education researchers and practitioners have worked to understand how to best include young children with disabilities in the early childhood education settings, not as learners who are merely present in the classroom alongside their typical developing peers but as active participants who have equitable opportunities to co-engage in high quality learning activities. However, while there has been critical movement toward increasing the accessibility of technologies in HCI, this field is still lacking in the design and research of technology that works to support equitable, inclusive co-engagement between

children with *and* without disabilities. In this dissertation, I aimed to begin to fill this gap by researching how collaborative technology can be designed *inclusively* to support neurodivergent and neurotypical children in playing together.

By integrating theories and methods from design, HCI, disability studies, early childhood inclusive education, and the learning sciences, I considered how to design technology for inclusive play that takes into account the needs of neurodiverse children and the adults who support them during play. After I gained a foundational understanding of these people who would directly and indirectly use and support the use of technology for play among neurodiverse children, I iteratively designed an application for inclusive play called Includle, evaluated the feasibility of specific design features of the application, and examined Includle's use by neurodiverse children at different stages of my design process. During my research, Includle became a coordinative artifact that allowed me to ask and answer questions about what design is doing to facilitate equitable, participatory collaborative engagement and interactions for children with diverse abilities and needs.

Now, I prompt other researchers and designers to consider how their designs may facilitate or act as barriers to this type of collaborative engagement. How do our ideas about inclusivity and equity get embedded into what we create? How do these artifacts work within the social-material practice of multiple actors, including both people and things? Who or what is "responsible" for doing the work of inclusion in this context? When or in what situations? How might what we create be used in ways we do not intend to aid *or* inhibit children from equitably engaging, collaborating, learning, and/or participating? What are the impacts of specific design features and their prescribed notions of use?

Designing equitable, collaborative technology-based play experiences for neurodiverse children requires reflection and thoughtfulness as to how play occurs between neurodiverse children, or children with and without disabilities. My hope is that my work can disentangle some of the complexity of this "wicked problem" (Buchanan, 1992), unpacking how technology can be used a resource within neurodiverse

children's relationships and interactions (Jordan & Henderson, 1995), and can support children in equitable, inclusive, and participatory collaborative play for learning.

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APPENDIX A: INCLOODLE CONTENT

Appendix Table 1. Includle 1.0 content.

Social and Emotional Topic	Character Anecdote	Question	Prompt: Take a picture of yourselves...
Happiness	I feel happy when my buddies share with me.	What do your buddies do to make you happy?	...making happy faces.
Sadness	I feel sad when my soccer team loses our game.	What makes you feel sad?	...making sad faces.
Anger	I feel angry when sounds are too loud because it hurts my ears.	What makes you feel angry?	...making angry faces.
Embarrassment	One time I felt embarrassed when I tripped and fell in front of my friends.	What makes you feel embarrassed?	...making embarrassed faces.
Cheering up others	I like to give hugs to my friends when they're sad to cheer them up.	What do you do to cheer up your friends?	...making cheerful faces.
Frustration	I'm working on using my words instead of hitting or biting. When I have a hard time using my words, I feel frustrated.	What makes you feel frustrated?	...making frustrated faces.
Grumpiness	Sometimes I feel grumpy when I don't get enough sleep.	What makes you feel grumpy?	...making grumpy faces.
Calming down	Sometimes I can get very upset. Taking big deep breaths helps me calm down.	What helps you calm down when you are upset?	...taking a big deep breath.
Discomfort	Sometimes I feel uncomfortable and unsafe when my buddies touch me or get too close.	What makes you feel uncomfortable or unsafe?	...making uncomfortable faces.
Being scared	I feel scared when I'm in the dark.	What makes you feel scared?	...making scared faces.
Silliness	I feel silly when I stick out my tongue.	What makes you feel silly?	...sticking out your tongues.
Worry	I feel worried when my mom is late to pick me up from school. Being worried makes me scared and makes my stomach hurt.	What makes you feel worried?	...making worried faces.
What you are working on	I'm working on writing. I practice writing my letters every day!	What are you working on?	...with letters.
Favorite shapes	My favorite shape is a circle. I use a wheelchair, and my wheels are big round circles.	What are your favorite shapes?	...with a circle.
Favorite colors	My favorite color is green.	What are your favorite colors?	...with something green.
Favorite toys	I love playing with LEGO blocks.	What do you like to play with?	...with a LEGO block.

Appendix Table 2. Includle 2.0 content. Original character images created by ©Liz Aragon. Final images edited and produced by Lucas Colusso, Mackenna Lees, and me.

Character	Character Name	Social and Emotional Topic	Character Anecdote	Question (+ Tell each other!)	Prompt: Thanks for sharing! Take a picture of yourselves...
	Adele	Proud	I feel proud when I am a good friend and fill my buddies' buckets.	What makes you feel proud?	...making proud faces!
	Ashley	Favorite shape	My favorite shape is a circle. I use a wheelchair, and my wheels are big round circles.	What are your favorite shapes?	...making sad faces!
	Barika	Favorite number	I am working on counting numbers up to 100. My favorite number is 10.	What are your favorite numbers?	...with a number!
	Charlotte	Left out	I feel left out when my buddies play without me.	What makes you feel left out?	...making the face you have when you feel left out!
	Christina	Sad	I feel sad when I say bye to my dad when I go to school.	What makes you feel sad?	...making sad faces!
	Corey	Excited	I feel excited before I open presents on my birthday.	What makes you feel excited?	...making excited faces!
	Elena	Favorite animal	My favorite animal is an elephant.	What are your favorite animals?	...with an animal!
	Evan	Favorite toy or thing to play with	I love playing with LEGO blocks!	What do you like to play with?	...with my favorite toy to play with, a LEGO block!
	Gregory	Shy	Sometimes I feel shy when I meet new friends at school.	What makes you feel shy?	...making shy faces!
	Jason	What you are working on	I'm working on writing. I practice writing my letters every day!	What are you working on?	Since I'm working on writing, take a picture of yourselves with letters!
	Joey	Embarrassed	One time I felt embarrassed when I tripped and fell in front of my friends.	What is a time you felt embarrassed?	...making embarrassed faces!
	Lexi	Angry	I feel angry when sounds are too loud because it hurts my ears.	What makes you feel angry?	...making angry faces!

Character	Character Name	Social and Emotional Topic	Character Anecdote	Question (+ Tell each other!)	Prompt: Thanks for sharing! Take a picture of yourselves...
	Lily	Brave	I feel brave when I get a shot at the doctors when I know it might hurt.	What makes you feel brave?	...making brave faces!
	Lucas	Scared	I feel scared when I'm in the dark.	What makes you feel scared?	...making scared faces!
	Maya	Grumpy	Sometimes I feel grumpy when I don't get enough sleep.	What makes you feel grumpy?	...making grumpy faces!
	Mia	Frustrated	I'm working on using my words instead of hitting or biting. When I have a hard time using my words, I feel frustrated.	What makes you feel frustrated?	...making frustrated faces!
	Nikki	Cheering up others	I like to give toys to my friends when they're sad to cheer them up.	What do you do to cheer up your friends?	...making cheerful faces!
	Ray	Uncomfortable/unsafe	Sometimes I feel uncomfortable and unsafe when my buddies touch me or get too close. I need more space.	What makes you feel uncomfortable or unsafe?	...making uncomfortable faces!
	Rohan	What others do to make you feel happy	I feel happy when my buddies share with me.	What do your buddies do to make you happy?	...making happy faces!
	Sarah	Favorite colors	My favorite color is green.	What are your favorite colors?	...with something that is my favorite color, green!
	Sebastian	Loving	I feel loving when I hug my baby sister.	What makes you feel loving?	...making loving faces!
	Toby	Worried	I feel worried when my mom is late to pick me up from school. Being worried makes me scared and my stomach hurt.	What makes you feel worried?	...making worried faces!
	Tomas	Grateful	I feel grateful that my buddies try to be bucket fillers.	What makes you feel grateful?	...making grateful faces!
	Trevor	Calming down	I can get very upset. Taking big deep breaths helps me calm down!	What helps you calm down when you are upset?	...taking a big deep breath!
	Tselil	Silly	I feel silly when I stick out my tongue.	What makes you feel silly?	...making silly faces!

APPENDIX B: TRANSCRIPTION CONVENTIONS

- [A *left bracket* indicates where an overlap begins.

-] A *right bracket* indicates where an overlap ends.

- (.) A *dot in parentheses* indicates a brief gap between utterances.

- (()) A *double parentheses* contain the transcriber's descriptions of non-verbal behavior.

- () *Empty parentheses* indicate the transcriber was unable to hear and transcribe what was being said.

- (0.0) *Numbers in parentheses* indicate time elapsed in seconds and tenths of a second.

- A *dash* indicates a cut-off.

WORD *Uppercase* letters or words indicate louder talk relative to the surrounding talk.

VITA

Kiley Sobel completed her PhD at the University of Washington in the Department of Human Centered Design and Engineering under the advisement of Julie A. Kientz, PhD in 2018. She was supported by the National Science Foundation Graduate Research Fellowship Program (NSF GRFP). Over the course of her academic career, she also had the pleasure of working with Jason Yip, PhD's KidsTeam UW at the University of Washington, foundry10 in Seattle, WA, The Joan Ganz Cooney Center at Sesame Workshop in New York, NY, and Microsoft Research in both Bangalore, India and Redmond, WA. Her work has been published at various ACM conferences, including Human Factors in Computing Systems (CHI), Interaction Design and Children (IDC), and Computer-Supported Cooperative Work and Social Computing (CSCW). She received her BS from Harvey Mudd College.