Immersive Media Environments for Special Education:

Developing Agency in Communication for Youth with Autism

by

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ABSTRACT

This dissertation describes the development of a state-of-the-art immersive media environment and its potential to motivate high school youth with autism to vocally express themselves. Due to the limited availability of media environments in public education settings, studies on the use of such systems in special education contexts are rare. A study called *Sea of Signs* utilized the Situated Multimodal Art Learning Lab (SMALLab), to present a custom-designed conversational scenario for pairs of youth with autism. Heuristics for building the scenario were developed following a 4–year design-based research approach that fosters social interaction, communication, and self-expression through embodied design. *Sea of Signs* implemented these heuristics through an immersive experience, supported by spatial and audio-visual feedback that helped clarify and reinforce students' vocal expressions within a partner-based conversational framework. A multiple-baseline design across participants was used to determine the extent to which individuals exhibited observable change as a result of the activity in SMALLab. Teacher interviews were conducted prior to the experimental phase to identify each student's pattern of social interaction, communication, and problem-solving strategies in the classroom. Ethnographic methods and video coding were used throughout the experimental phase to assess whether there were changes in (a) speech duration per session and per turn, (b) turn-taking patterns, and (c) teacher prompting per session. In addition, teacher interviews were conducted daily after every SMALLab session to further triangulate the nature of behaviors observed in each session. Final teacher interviews were conducted after the experimental phase to collect data on possible transfer of behavioral improvements into students' classroom lives beyond SMALLab. Results from this study suggest that the activity successfully increased independently generated speech in some students, while increasing a focus on seeking out social partners in others. Furthermore, the activity indicated a number of future directions in research on the nature of voice and discourse, rooted in the use of aesthetics and phenomenology, to augment, extend, and encourage developments in directed communication skills for youth with autism.

DEDICATION

This work is dedicated to my younger sister, Dana Grace Tolentino, whose presence, laughter, and unbridled authenticity has helped me find my own way in this world.

To anyone whose life has been touched by, or has yet to be touched by, someone labeled with any disability: may you find in this work an opening that helps you discover new ways to listen.

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PREFACE

Coming to Terms with Special Education

When I first chose to work with a high school special education community, in my mind, I had a naïve picture of special education. When I was living at home in the years between graduating with an undergraduate computer science degree and returning to school for a master's in music, I would take my younger sister to an adult school for folks with disabilities. When I walked my sister into her homeroom, the teacher, staff, and students warmly greeted her with smiles as she ran to her seat with excitement. Having attended an excellent public education program when I was growing up, I was quick to assume that the people in the classroom would take good care of my sister and that she would come home having learned something our family could not teach her.

One day I noticed that she had brought home an assignment to help her practice writing her name, and a semester report card saying she had earned all A's with one B. Both seemed completely arbitrary, and I was slightly incredulous, because in all 26 years of life, as much as my parents and I tried with her, she had never been able to successfully write the four letters of her name. I wondered why they weren't more successful at teaching her something useful, like putting items away after she was done using them, or brushing her teeth. But as a sibling, what did I know? Who was I to question? I could not possibly be an expert.

Having a Sister Labeled with a Disability

In the mid-1980s, my younger sister was labeled with what was then called *severe mental retardation*, which is known today as *intellectual disability*. She has difficulty making clear speech and forming coherent sentences with her voice. This means that when she tries to share her wants or needs with you, unless you know her lingo well, you must find creative ways to get her to show you what she means. Her speech is nuanced, associative, and playful. It is up to you to decode her speech so that you can meet her preferences, desires, and requests. What further fascinates me is that though she struggles to speak, she is bilingual in her listening skills, understanding both English and Ilocano, my parents' native language, which is regional to the northern Philippines. Nonetheless, the everyday reality is that she will always need someone to manage her care and plan for her most basic needs to be met.

When we were children, she was very vocal, trying out lots of words and loud sounds like any other child. Over time, however, we heard her voice less and less. She would give a shy smile with her head facing down and eyes peering up occasionally, quietly observing others during family gatherings and speaking up only when prodded or impacted emotionally. Music would sometimes trigger her into singing or giggling out loud. I sometimes wondered if she kept her voice down and to herself because she grew tired of the curious but confused looks that people gave her when they could not understand her. I can never know for sure, but only empathize, having watched her encounter others and struggle to be heard.

My sister's limited voice affects how people interact with her. Along with general interest and mild confusion, looks of fear, concern, and sometimes disgust would come from others. These looks often caused her cry. Ultimately, this interaction paints her as a shy girl with little or nothing to say. She took fewer risks in using her voice. Her voice receded into the background like a shadow that was masked and went unnoticed in the harsh light. Because the voice impacts how others perceive us, developing the voice continues to stand a key tool in advocating for others and ourselves.

First Exposure to Experimental and Contemporary Music

Having grown up playing classical music for violin and piano, my encounters with avant-garde music halfway through college both shocked and fascinated me. What I found most powerful about experimental or contemporary music is that it broke every rule about what I understood to be "good" music and followed a rubric of expression that was quite different from the Western classical tradition. In the vein of conservatory music training, precision, speed, virtuosity, and adherence to accepted performance practices earned high marks; in effect, high musical standards were akin to top athletic competitions. In contrast, critical, avant-garde, or otherwise experimental music practice attempts to question and challenge classical forms by playing with, appropriating, and often times, discarding traditional notation and paradigmatic performance. A performer's musical accuracy is less important than the quality of his or her interpretation of a musical text; thus, a given performance must stand apart from those before it as its own, critical, provocative, and compelling experience. If a performance succeeds by these measures, then the significance of the performer's hand in bringing a work to life comes through as the score recedes.

The art of interpreting contemporary music – perhaps percussion works in particular – is to make sense of abstract texts by playing with combinations of sonic textures, gestures, and arrangements of physical materials (instruments) in space. Performers compile and take ownership over material in an attempt to deliver a cohesive and meaningful experience for both performer and audience. The goal of the performance is to instantiate an emotional, transformational, or otherwise affective experience that resonates in memory, which, when revisited in the mind, can change, mature, and continue to influence over time.

Computational Linguistics and Conceptual Blends

Before I ever laid hands on a drum, I studied computer science. As much as I initially struggled with this kind of pure abstract thinking, I quickly learned that succeeding required me to learn how to think very logically, in patterns and code. During my junior year of college at UC San Diego, I began a research project with the late Professor Joseph Goguen (Computer Science, PhD). Prof. Goguen's research drew influence across many disciplines, including computational linguistics and sociology, thus, he gave me a project on meaning and metaphor. Following on his theory of algebraic semiotics, a concept built upon the idea of using computational linguistic operations such as conceptual blending (Fauconnier & Turner, 2002) to mimic human metaphorical constructions, he also took interest in how such a process could be used to generate better poetry[1].

During my work on the project, I took Gilles Fauconnier's computational linguistics course at UCSD to better understand how conceptual blending takes place. *Conceptual blending* is, in effect, the process of (1) starting with two conceptual spaces; (2) deciding on what constitutes the

[1] Goguen's work in this area continued forward through the work of one of his former students, Prof. Fox Harrell, an Associate Professor researching computational narratives and artificial intelligence at MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL).

most generic concept space; (3) parsing each of the two concepts into its core objects and relationships; and finally (4) extracting and recombining the objects and relationships within each space to yield new concepts, a.k.a., conceptual blends (Fauconnier & Turner, 1998; Turner & Fauconnier, 2002) or metaphors. Conceptual blends are operations that humans perform in their heads that lead to results not unlike what we call metaphors, irony, clever advertising, jokes, and fables.

Following my brief encounter with computational linguistics, I developed a tendency to map and overlay what seemed like disparate concepts from one domain onto another to see what new metaphors might emerge. This method of engaging in metaphorical cross products for conceptual discovery is now part of my experience in the search for new insights regarding domain-specific phenomena.

Media Arts as a Path into Special Education

I undertook this graduate research with the desire to integrate my experience as a sibling of someone with disabilities with the experimental sensibilities of experimental percussion and the technical potentials of computer science. To interleave perspectives from the contemporary music genre into the design of educational experiences is to develop creative interventions that have the potential to catalyze change and deeper learning at a cultural level (Tolentino, 2007, 2012; Tolentino, Kelliher, Birchfield, & Stern, 2008).

It is my hope that this work contributes to the field by expanding the nature of learning opportunities for children who may otherwise have limited access to an enriching education.

CHAPTER 1

Introduction

Every child has a voice that is uniquely his or her own. I believe that one's voice is inextricably linked with one's identity, and that the quality of a person's voice has the potential to influence how others perceive, communicate, and connect with a person. By extension, developing one's voice is central to developing a solid self-concept and one's relationship to, and with, others. For a young individual with autism, simply using one's voice to communicate presents many challenges. For a young individual who is labeled with autism, the opportunities to exercise one's voice become even more constrained, as the label itself draws boundaries around the people, places, and contexts through which the child is seen and heard.

In public education, young individuals identified as severely autistic are enrolled in special education programs meant to help them manage negative behaviors while learning more socially accepted ones. However, in an effort to bring students' behaviors into compliance, such programs can also curb or limit children's natural tendencies toward speech. The structure of the classroom begs certain kinds of expressions or behaviors that must align with completion of educational tasks. As a result, students' expressions can be stymied before they flourish, corrected before they are acknowledged, and silenced before they are fully heard.

In science and medicine, autism is best known as a diagnosed disorder of ritualistic or repetitive behavior coupled with social and verbal communication difficulties (*DSM IV-TR* 2000). Persons with autism are often talked about in ways that pejoratively interpret their bodies based on their ability to perform and conform to normative standards in certain contexts (Biklen, 2006). These contexts, which are social, cultural, and physical, set a stage upon which rules of everyday performances unfold. Individuals who cannot master the implicit rules of these contexts are pitted against a rising social stigma that competes with his or her true identity, one that gets socially discredited and replaced by stereotypes (Goffman, 1963). Rather than inviting inquiry into the nuanced perspectives that persons living with autism possess, the stigma does the opposite by sanctioning their perspectives as incomplete, unworthy of regard, or impaired.

Technology has become an equalizing force in the way of opening up opportunities to demonstrate competence (Brodin, 2010) and eliminate stigma. It has demanded that society shifts its perceptions of what was once thought to be the limits on what individuals with autism could do. With the recent rise of digital media and technology-based contexts such as touch screens, Second Life, and social media, people with autism are participating in new contexts within which their voices can be heard[2]. Computer environments such as collaborative virtual environments and virtual reality have become recognized as effective, transformative spaces for learners with autism because they offer support in the form of direct control, a safe place for social skills practice, and a sense of presence (Moore, Cheng, McGrath, & Powell, 2005; Parsons & Mitchell, 2002; Parsons, Mitchell, & Leonard, 2004; Wallace, Parsons, Westbury, White, & Bailey, 2010). Autonomous robotic agents in the AuRoRA project (Autonomous mobile Robot as a Remedial tool for Autistic children) have helped to empower young participants with autism to initiate communication with peers (Dautenhahn, Werry, Rae, Dickerson, Stribling, & Ogden, 2002; Hudlicka, 2003; Robins et al., 2010). Even before these more recent developments, assistive and augmentative communication devices (AACs) were created out of the field of architecture's push for accessibility and universal design—a push that bled into new thinking about technology for educational accessibility (Edyburn, 2003).

In 1984, the Center for Applied Special Technology (CAST)[3] was created to lead the development of educational products, classroom practices, and policies that sought to expand the opportunities for all individuals through Universal Design for Learning (UDL). Drawing upon theories from neuroscience, digital technology was seen as a key component in UDL curriculum; technology was a medium that could uniquely deliver flexible educational services in ways that activated multiple learning paths in the brain by allowing for multiple representations of content (Rose, Meyer, & Hitchcock, 2005). With respect to technological advancement, most of CAST's

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[2] Portable touch table devices with AAC software are becoming popular choices for use in special education (McClaskey and Welch 2008), because the devices provide greater agency with which to communicate with others in everyday contexts. A 2011 CBS 60 minutes broadcast featured this point in its segment, "Apps for Autism."

[3] Center for Applied Special Technology (CAST), http://cast.org, Accessed April 7, 2013.

efforts have focused on translating text-based products into audio or visual representations for wide dissemination, broadening content through digital books, games, tutoring systems, and lesson planners.

Though efforts have mounted to build more effective instructional and assistive technologies, the implementation of these technologies may still be missing a key step in their design: a layer of interaction that supports identity work for its users. Instructional technology designers acknowledge and view their products as both influential, and influenced by, what Bourdieu (1972) would see as the structures that structure society. From this perspective, designers can begin to approach instructional technology design from a more critical perspective. In this way, instructional design becomes both a culturally conscious and aesthetic act on society. New technologies can be designed to help lift the sociocultural stigma that might otherwise plague its users. Together, pedagogy and technology then have the potential to evolve and not only improve behavioral outcomes, but to strengthen and affirm the self-concepts of its users.

Only recently has the aesthetic design of pedagogical tools been formally investigated and found to have a profound impact on the cultural dimensions of a learning experience (Parrish, 2008, 2009). However, researchers in human-computer interaction (HCI) and game design have been aware of the practical influence of aesthetics on engagement for decades. Commercial game designers have developed working formulas for creating sets of rules that evoke core experiences, or a core aesthetic, when players apply the rules to game play (Brathwaite & Schreiber, 2008; Bjork & Holopainen, 2004; Hunicke, LeBlanc, & Zubek, 2004). A methodology of Critical Technical Practice in HCI has been used to systematically discover ways in which the physical form and function that technology takes impacts the degree to which we feel or perceive conditions like intimacy or close connection with another person (Boehner, David, Kaye, & Sengers, 2005). Just as the rules of a classroom can elicit certain types of feeling or aesthetics about school culture, an alternative learning environment such as a virtual or immersive environment could embed new sorts of rules to encourage the kind of experiential learning that may be missing from the classroom.

Overview

This dissertation describes how an embodied learning experience in an immersive media environment served as a catalyst for speech and social interaction for three high school participants with autism. The experience, called *Sea of Signs*, was designed for the Situated Multimedia Art Learning Lab (SMALLab)—a classroom-sized, mixed-reality platform that lets designers synthesize motion capture data with data from custom input devices to create immersive, audio-visual feedback through quadraphonic audio and top-down visual projection. *Sea of Signs* implemented heuristics that were derived from a 4–year transdisciplinary, design-based research (DBR) approach to experiential media for education. Principles from HCI design, autism research, video game design, and Gestalt psychology provided a starting point for augmenting a conversational exchange through audio-visual projection. This work yields a theory of embodiment for immersive environments that unites a phenomenology of voice with multimodal design that reinforces presence, agency, and immersion of the physical body through dynamic media.

In the experimental phase of this research, *Sea of Signs* is implemented as a daily activity for three students with autism. A multiple-baseline design across participants was used to determine the extent to which individuals exhibited observable change as a result of the activity. Results for the study are presented and discussed, describing the degree to which a functional relation was established between the intervention and changes in participants' patterns in vocal communication and social interaction.

Problem Statement

Three core issues motivate the problem space that *Sea of Signs* seeks to address. The first issue has to do with designing for people with autism due to distinctive cognitive, sensory, and socio-communicative differences these individuals may possess. The second issue describes the tendency of persons with autism to have difficulty generalizing or transferring skills. The third issue confronts special education as a historically restrictive environment for teachers and students.

Autism: a cognitive, multi-sensory, social-communicative challenge. For youth diagnosed with autism, communicating and interacting socially with others poses problems for reasons that are not universal and yet unclear. This diagnosis is given to a child when he or she demonstrates a combination of verbal communication difficulties; patterns of restricted repetitive interests that prevent him/her from engaging in new tasks; and/or distractibility that prohibits sustained social interaction. Some individuals learn to communicate using picture cards or AAC devices. However, for reasons ranging from living independently, to seeking basic needs, to gaining access to quality-of-life experiences that may be otherwise difficult to obtain (Burgess & Gutstein, 2007; Farrugia 2009), developing one's voice remains a core objective for many of the students under this label.

Individuals with autism are also known to experience difficulties managing multiple streams of sensory input in a given environment, which can cause them to become over-stimulated. People with autism can experience hypo- or hyper-sensitive sensory perceptions that challenge their ability to digest relevant stimuli in the environment without becoming overwhelmed (Bodashinga, 2003). To solve this problem, teachers have applied strategies, such as University of North Carolina's structured teaching method TEACCH (2013), founded in 1972, for physically arranging classrooms and activity schedules to be more predictable with the help of visual aids. Although physical restructuring may work for more permanent spaces, the ability to transform a digitally enhanced environment grows exponentially.

Recent research in autism and cross-modal integration by Silverman, Bennetto, Campana, and Tanenhaus (2010) identified audio-visual integration as a precursor to speech-gesture integration in persons with autism. This finding suggests that learning systems that couple auditory elements with visual ones increase the potential to advance speech and gesture for individuals with autism. Experiential media design that draws upon this insight can potentially help individuals manage and integrate multiple input streams in two ways—either by strongly coupling sensory streams or by limiting exposure to them through a minimalist design aesthetic. Following from principles of Gestalt psychology, coupling streams helps us perceive two distinct elements as one, whereas creating lines (audio or visual) that connect one or more elements helps to draw our focus. The creators of the multi-sensory, room-sized environment MEDIATE (Multisensory Environment Design for an Interface between Autistic and Typical Expressiveness) successfully used visual Gestalts to design particle interaction models that would respond based on children's presence (Parés et al., 2006). They reported that young children with ASD were able to play with tactile wall interfaces to creatively explore and interact with dynamic visual particle systems (Parés et al., 2004; Parés, Masri, van Wolferen, & Creed, 2005). *Sea of Signs* expands the work in immersive media environments and autism by studying the degree to which an aesthetic design framework can also embed socio-communicative learning goals, as a way of increasing participant's agency towards communication and self-expression.

Developing interventions for transferability. There is a general fear regarding the use of new tools. Some opponents of technology argue that the use of tools will lead to dependencies. This issue is particularly sensitive with respect to teaching individuals with autism because such individuals may have difficulties with abstracting or generalizing learning across contexts. The theory of embodiment and embodied design presented in this dissertation suggests that the use of immersive media can actually solve this situation by promoting the concept of projective identity that Gee (2007) has set forth as a blend between a virtual and real-world identity (Gee, 2007, pp. 49–54). This sort of identity, enacted in activity that is experienced as a distinctly different environment, provides space for a participant to encounter an augmented version of himself or herself, in the presence of other peers. My hypothesis is that a participant's somatic memory, strengthened by the audio-visual manifestation and affect of the experience, will effectively enable him or her to recall practiced skills outside of the original learning context. Because a participant's peer is built into the experience, that peer also serves as a trigger for recalling these skills once they both return to the regular classroom.

Special education environment as a regulatory context. Improving socio-communication outcomes for youth with autism is not limited to new interventions alone. The root of the problem also comes from an institutional perspective on disability, a position that has historically chosen to teach individuals with disability in a segregated context. The special education environment was originally and exclusively built around the concept that students must first learn methods for regulating and controlling what standardized assessments have determined to be non-normative behavior, before they can rejoin their typically developing peers in class. This perspective remains at work today and is well-documented as a deeply embedded sociocultural phenomenon infused with a general fear of persons who speak, look, and/or act differently from the accepted norm. (Schweik, 2010; Snyder & Mitchell, 2006) In fact, not until the U.S. Congress enacted the *Education for All Handicapped Children Act* in 1975 was the public education system treated as a surveillance tool for identifying and transferring individuals with disabilities into mental institutes for permanent hospitalization. This act was a precursor to today's *Individuals with Disabilities Education Act* (IDEA), which mandated the end of this practice for all youth with disabilities and granted these children equal rights to educational access and opportunities to learn.

Since then, special education classrooms have redirected their focus to helping students improve behavioral outcomes by following Individualized Education Plans (U.S. Department of Education, 2007). However, students' clinical diagnoses continue to govern the daily structure of their lives, serving to reinforce and maintain historical relationships between special education environments and cultural isolation and stigma endemic to institutionalization. Research from the early 1990s produced substantial evidence that showed "people with severe disabilities do not thrive in isolated programs and settings;" they achieve less, meanwhile suffering from "the loneliness and lack of choice imposed upon them" (Ruppmann, 1991, p. A16, cited by Connor & Ferri, 2007, p. 66). IDEA advocates for inclusion and the placement of youth with disabilities in the least restrictive environment. However, debates about what this should look like continues as special education classrooms have become paradoxical spaces where they are idealized as entry points into general education and safe havens from an unsympathetic general education system (Connor & Ferri, 2007).

What this means for culturally conscious approaches to technological and instructional design is that designers must find ways to fracture institutionalized barriers while working within pre-existing contexts. One approach to this problem—the approach that is studied and described in this dissertation—is to create learning experiences within sub-contexts or sub-environments that resist external structures by using aesthetics to alter or open up the frame around what is expected or desired. Indeed, researchers in special education are calling for greater research into learning environments that can promote and sustain persistence, flexibility, curiosity, and empathy toward peers (Wolery, 2000).

Purpose of the Study

The purpose of the study was to explore the extent to which the *Sea of Signs* experience for the SMALLab immersive media environment could motivate pairs of youth to express themselves vocally. A multiple-baseline design across participants was used to determine whether there was a functional relationship between speech outcomes and the SMALLab activity. Informal teacher interviews and ethnographic data were collected and synthesized to produce profiles of participants' behaviors prior to and during the experimental phase. Interviews were conducted daily with teachers during the experimental phase to cross-reference with observed behaviors and to probe whether participants' socio-communicative styles were changing in the regular classroom. Each session was video coded to determine the mean percentage of speech durations during a given condition. The percent duration of teacher prompts per session were also analyzed to explore whether prompting tendencies changed throughout the experimental phase. In addition, novel and emergent socio-communication behaviors, as well as the teacher's perception of her role, is discussed in the section on limitations and future work.

Sea of Signs was introduced to participants in two stages, following a baseline stage:

- A baseline stage, the goal was to place students in a condition that was a minimal simulation of the pair-wise activity minus the core immersive media of *Sea of Signs* for SMALLab.
- A stage for self-expression in SMALLab, in which the goal is to encourage individuals to speak freely. This first setting was designed for a participant to get physically situated in the environment and learn how to speak into a microphone to generate colored visual particles around him/her.
- A stage for connecting with others in SMALLab in which the goal is motivate seeking participants to seek out their partner to communicate. The second setting was designed

to bring a participant's focus toward his or her partner: a stream of particles and a picture of the speaker would travel along a track or straight line toward the partner.

Hypothesis

If the *Sea of Signs*' embodied design aesthetic is successful in augmenting and reinforcing natural vocal expression by generating an audio-visual presence for the voice, participants will demonstrate greater self-expression in the first setting. If the *Sea of Signs*' design successfully implements the media feedback to provide participants with a sense of reciprocity and connectedness, participants will continue to seek out their partners with a decreasing need for teacher prompts. The immersive nature of the environment will be different enough from their daily classroom environment that participants will feel comfortable breaking from their typical interaction patterns to engage in self-expression and sustained dialog with another person.

For learning in the scenario to occur, a participant must experience enough agency, ownership, and control to successfully use his or her voice to dynamically manipulate the environment.

The efficacy of the scenario was evaluated in two ways. First, *Sea of Signs* was evaluated as a learning intervention based on the extent to which youth demonstrated improvements in social and vocal behavior. *Intent to communicate* was evaluated based on calculating percent durations across conditions, based on speech acts and the ratio of speaking to the duration of turns. Youth must initiate and maintain interaction with the system and/or partner with reduced help from the teacher.

Further generalizable knowledge was gathered from any substantial changes in the teachers' own perceptions and expectations of the students, including how to improve pedagogy, as well as future uses or improvements of technology for classroom activities. The following provides a roadmap of this document.

Chapter 2*, Transforming Habitus through Projective Identity*, places the work in a broader philosophical context. Pierre Bourdieu's (1972, pp.72-95) concepts of *habitus* and *field* are the context for why any technological innovation or intervention for special education youth must critically reflect upon its treatment of embodiment if they are to transform cultural patterns of deficit-model thinking. Thinkers from disability studies and phenomenology are asking for a new approach to intervention design that utilizes aesthetics to change how persons with disabilities both view themselves, and are viewed by, others. James Paul Gee (2007) develops the concept of a *projective identity* (pp. 48-54) as a type of hybrid identity a person perceives when he fuses his or her real world identity with a video game character he or she plays. If learning interventions can instantiate this phenomenon within disabled youth, I propose that these youth will have a unique opportunity to grow and extend themselves beyond their roles in special education. The phenomenological concepts of field, focus, and horizon (Ihde, 2007, p. 35-45) intersect with Bourdieu's thinking tools to create an alternative framework that favors aesthetic development of learning interventions.

Chapter 3, *Embedding the Voice in Immersive Media Contexts* moves the discussion from projective identities to the manifestation of voice in immersive experiential media systems. It connects Ihde's phenomenology of voice and sound with aural and visuo-spatial feedback and presents a set of heuristics for designing an immersive media experience based on the voice. A discussion about embodied design is presented, with *presence* being the core goal of an embodied experience, that occurs based on the extent to which a person feels *immersed* and has *agency* within that environment. This theory is then applied to designing a social activity in SMALLab that helps to emphasize the voice. This chapter sets the compositional framework for creating *Sea of Signs*.

Chapter 4, *Experiment and Scenario Design* describes the experiment in detail, including its construction, its aesthetic conception, and its link to design principles. This includes descriptions of the hardware, software, microphone interface, and findings from pilot studies that originally motivated and guided the design. Experimental methodology, variables, and measurements are also described.

Potential Contributions

Results from this study contribute in three key ways. First, this study expands an understanding of embodiment and its implications for learning design. This theory also applies beyond education and persons with disabilities to support media technology use in larger social, creative and/or rehabilitative spaces. This study makes a case for expanding research into hybrid, technologically enhanced educational environments that can be customized to include greater diversity of learning styles.

Second, it provides the fields of special education, assistive technology, and education policy with a working example of how aesthetics opens up pedagogy and technological interventions in ways that resist stigma embedded in traditional curricula and technology design. Purely behavioral approaches to autism are first de-centered, and then re-imagined in a contemporary context, where media stimuli are designed to value the presence and contribution of its users. This creates inroads for disability studies and the arts to play a greater role in developing new kinds of interventions for inclusion and/or special education.

Finally, this study highlights an opportunity for HCI and video game design research to examine voice as an important and under-explored aspect of embodied media design.

Scope

The study took place at a high school where SMALLab is installed in a classroom. Participants included eight students divided into four dyads based on students' current pairing for regular speech therapy. Two teachers participated: (1) the head teacher, who taught her regular class during the study but was interviewed before and after students participated in SMALLab; and (2) a para-educator, who helped facilitate interactions in SMALLab and guided students to and from sessions. Two independent variables were manipulated in sequence to produce audio-visual feedback for the conditions of presence (self-awareness) and self in-relation-to other.

The study lasted five weeks during regular school hours, where pairs would participate in SMALLab 1–2 times per day, for approximately 10–15 minutes per day, every day. A mixed methodology was used, including participant observations in a multiple-baseline design across settings and follow-up interviews with teachers. Teacher interviews were taken following each day of sessions to help decode behaviors during the intervention. Informal teacher interviews were also taken prior to the study to drive thick descriptions about each student's typical patterns of communication and social interaction in class.

Video recordings were transcribed and analyzed, along with audio recordings from a hand-held shell object containing a microphone that was passed between students. Audio data was used to analyze the clarity and content of their communication in SMALLab.

Background and Approach

This dissertation built upon a 4–year relationship with a team of special education teachers, special education students, education researchers and media designers. The members of this Professional Learning Community (PLC) focused on supporting learning goals for special education students as part of the research agenda of the K-12 Embodied and Mediated Learning Group (EML)—an application area at the School of Arts, Media and Engineering School (AME). Between 2008 and 2010, I led the Special Education PLC in a collaborative, iterative design process that produced four SMALLab pilot scenarios for engaging 1 to 2 participants. All scenarios sought to target a central learning goal: to promote social interaction and communication in students. Chapter 4 elaborates on these pilot scenarios and findings.

The EML group's core focus has been on improving how embodiment is understood in the context of embodied learning design using a mixed-reality environment. SMALLab scenario design is currently guided by a collection of general design principles focused on linking dynamic media with whole-body movements (Birchfield et al., 2008; Johnson-Glenberg, Birchfield, Megowan-Romanowicz, Tolentino, & Martinez, 2009). This dissertation contends that this current definition of embodiment is directly linked to how learning designers include, or exclude, people based on our expectations and interpretations of their bodies. By expanding the embodiment discourse to include the dimension of voice, the potential for embodied learning opens up to persons for whom whole-body gestures are too demanding or complex to perform.

The study takes place during the regular school year in accordance with student and teacher availability. The scenario design is grounded in an iterative, multi-year design process influenced by visual Gestalts, game design, and HCI. The methodology for this study reflects a critically conscious, transdisciplinary attempt to generate positive and constructive opportunities so people with cognitive differences can experience each other anew with technology.

CHAPTER 2

Transforming Habitus through Projective Identity

This chapter presents the theoretical framework for the *Sea of Signs* study, integrating perspectives from disability studies and phenomenology of sound with sociocultural perspectives on learning environments.

Bourdieu's concepts of habitus and field theory (Bourdieu, 1972, pp. 72–95) frame historical roots of special education to explore how its early beginnings have led to patterns of schooling that minimize freedom of expression of students. Ihde's phenomenology of sound describes the voice as embodied and co-constituted through social interaction. His aesthetic, non-reductionist approach to the voice suggests an alternative framework to developing more human-centered learning experiences for youth in special education that enable them to see and hear each other in a different light, positing self-expression as central.

The concepts of inner speech and thinking in language are merged with the insight that people with autism think directly in patterns and pictures—what autism activist Temple Grandin, PhD, (1995) calls *thinking in pictures* . If we accept that people with autism are inclined towards visual learning, it follows that dynamic visualizations could be used to strengthen socio-communicative learning opportunities. By focusing on vocal self-expression as central to communication, we can design interaction in which a person's voice is dynamically and effectively embodied through an immersive media environment. This gives users a chance to discover and appreciate their voice in new ways through alternative modalities.

An immersive media experience may in some ways be likened to experiences with video game play. In what Gee (2004) describes as well-designed video games, a phenomenon called projective identity can emerge as a person plays the game. Projective identity describes a kind of hybrid identity that fuses a person's real-world identity with that of a video game avatar. The person identifies with the avatar, both by projecting values onto it, as well as taking on characteristics that the avatar possesses. An immersive media experience can leverage this phenomenon by incorporating a person's physiological self into the interaction.

If a participant feels immersed in, anchored in, and augmented by dynamic media feedback, there exists a potential for subtle identity work to be done. We can imagine that a physical person is both the real-world player and a digitally augmented or extended version of him or herself. The environment super-imposes one's mediated self with one's mundane self, resulting in a projective identity that is somatically and affectively impressed upon a person. For persons with autism, the projective identity theory suggests an environmental mode of learning that supports their visual strengths in ways that cannot be achieved in traditional, physically static environments. To summarize, the proposition is that an embodied experience in an immersive media environment may promote self-actualization through projective identity.

A Phenomenological Approach to Learning Design

Grounding an approach through personal experience. My personal background, set forth in the preface of this document, informs my reasons for grounding this theory in a phenomenological and sociocultural approach. Here, I elaborate on the processes I use to link my prior experience in cognitive linguistics and experimental music performance with my approach to experiential media design for special education.

Conceptual blending as a tool for finding blending theoretical spaces. Cognitive scientists Mark Turner and Gilles Fauconnier (1998) proposed a theory of conceptual integration, a.k.a. conceptual blending, to describe a general cognitive operation to yield new conceptual spaces. At the core of conceptual blending is selective projection, which occurs when "structure from input mental spaces is projected onto a separate, 'blended' mental space" (Fauconnier & Turner, 1998, p. 133). A conceptual blend can be thought of as a mental simulation of cross-space mappings that leads more elaborate, emergent concepts like metaphors, good jokes, clever advertising, and even fables.

Blending is useful in contextualizing this study for two reasons. First, it describes my process for interlocking a phenomenological approach with a critical theorist approach to create a framework for critically examining a field, before pivoting into expanding that field. Following Ihde's (2007) framework, field expansion, or movement towards the horizon of knowledge in a given domain, can occur by focusing on a select set of behaviors, and then examining fringe behaviors through transdisciplinary means. Second, it describes my process for crafting a theory of learning that enables the integration of Gee's and Vygotsky's sociocultural theories with autism research and disability studies, resulting in what I term as Autism Spectrum Disposition, or ASD_2, which will be described later in this chapter.

Applications of avant-garde music performance to research and interaction design. There are relevant insights that experimental music performance can bring into educational research, which I will describe here, beginning with a metaphor between musicianship and scholastic achievement.

Traditional music conservatories typically guide and train students toward athletic kinds of performances, i.e., performances of precision, dexterity, virtuosity, and adherence to established performance practice. Avant-garde music practice, also known as experimental or contemporary music practice, seeks to provide a critical and alternative response in order to transform and evolve traditional forms. If we look at special education as having its own conservatory mentality, we might see that the classroom's rigid structures might favor only certain kinds of behavioral performances—performances of function, order, accuracy, and adherence to socially accepted behavioral norms. To bring a critical or radically innovative approach to the classroom might be necessary for transforming and evolving the clockwork structure of the institution.

Composers and performers of experimental music are constantly playing with and pushing the limits of traditional forms. Music gets tested in both subtle ways (e.g., the development of extended techniques) and more dramatic ones (e.g., Karlheinz Stockhausen's *Helicopter String Quartet* (1992/3), Jose Maceda's *Ugnayon* for 20 radio stations (1974) or *Udlot-Udlot* for up to several thousand people (1975). Composers often work closely with performers to produce musical scores in non-traditional notation, taking on multiple forms such as prose, sketched diagrams, graphs, or the throw of dice. At times, the score becomes more of a set of directions and suggestions rather than a static text, and is designed as such to give performers room to breathe and experiment within the piece. Performers who take up these kinds of pieces often then strive to construct an experience for its listeners, such that in witnessing the performance, the audience becomes fully engaged, intrigued, and perhaps at times, even uncomfortably provoked. These are measures for knowing whether the realization of a musical work has succeeded.

Just as composers are writing pieces that give performers greater interpretive agency, I conceive of my role as an interaction designer to be one of creating an experience where participants also have room to grow into an interaction. As participants adapt their role and begin performing or interacting, the teacher then can step back as a witness to their performance, to perhaps see or hear something new in his or her students. For me, this would be a personal measure of success in realizing a designed interaction.

Lucier and the extension of vocal phenomena through composition. From the outset of my work, American composer Alvin Lucier's work and self-stated phenomenological approach to composition (Lucier, 1995) has profoundly impacted my interest in manipulating the voice through digital media. In his book of prose scores, *Reflections: Interviews, Scores, Writings, 1965–1994* (Lucier, 1995), he includes two pieces, *Duke of York* (1971) and *I am sitting in a room* (1970), that involve the generation of real-time feedback loops over loudspeakers using live vocal recording, synthesis, and amplified tape playback. The goal of each piece is not to be performed or reproduced exactly each time. Rather, each piece asks its performers to provide a voice as input into a sonic process that unfolds over an extended period of time.

The score for *Duke of York* (Lucier, 1995, pp. 324–327) requires a vocalist and a person on synthesizer to compile a list of texts based on the real or imagined identity of the vocalist. The synthesizing player alters the person's voice in a way that brings the sound of the textual reading as close to the original as possible. Lucier's intent for the piece was to strengthen the relationship between the vocalist and the synthesist through this simple, personal, sympathetic, and imaginary form of communication (Lucier, 1995, pp. 116–127). A super-imposed or hidden identity of the vocalist is revealed as the synthesist helps to bring it forward (Tolentino, 2007).

I am sitting in a room uses a looped human voice to draw out the resonant qualities of the physical room where the piece is being played. The score (Lucier, 1995, pp. 312–315) requires a single person to first record a text of any length onto a tape. The recording is played back into the room through a loud speaker and simultaneously recorded, producing a second generation of the original recording. This second generation is then played back and recorded, resulting in a third generation, and so forth, for multiple generations. After about 45 minutes, the human voice is no longer intelligible, but the room shimmers and booms with the compound resonant frequencies that it has amplified.

Each piece creates a musical context in which the voice is transformed into an imaginative space where hidden phenomena are revealed. Features of identity and interpersonal relationships emerge in *Duke of York* by providing “an underground current … that connects people in ways that they never would otherwise” (Lucier, 1995, p. 126). Of *I am sitting in a room*, LaBelle (2006) suggests that the work “states a phenomenological fact: it points to an existential certainty, asserting physical presence as a condition of being” by finding its reinforcement and reassertion through audio recording and playback that follows the “uncanny removal of the body” (p. 129). Put differently, as it powerfully and sympathetically resonates, the room itself becomes an augmented, embodied extension of the voice.

LaBelle touches on another point that segues directly into the relevance of Lucier’s work to special education contexts. He identifies the therapeutic affect that *I am sitting in a room* provided for Lucier himself, who has a stutter. During performances, Lucier has spoken the recorded text with his own voice, which allows him to “exorcise his own somatic quivers” by giving the stutter “its own musicality through which the composer overcomes anxiety … to a point of composition, tonality, and spatial completion” (LaBelle, 2006, p. 129).

Thesis

My central thesis is that applying a musically avant-garde or phenomenological lens to the mode and content of students’ expressions will increase the quality of their self-expression. Learning opportunities would become creative contexts for experimentation as individuals’ unique characteristics and dispositions would serve as aesthetic points of departure. Others would also have an alternative framework through which to witness the quality of their expressions without the comparative bias of traditional or classical aesthetic lenses. This presents a paradigmatic shift for special education, one answers Susan Gabel’s (2005) call for the use of an “aesthetic of disability” in education.

This perspective emerges from my blended, subjective experience, as a sister of someone with disabilities, an experimental percussionist, a computer scientist, and a media arts researcher. My approach is to first gather and synthesize knowledge from outside special education, then use this knowledge to create opportunities for children with disabilities by dismantling and resisting culturally imposed stereotypes while working within the system. Because autism presents itself as a common denominator at the site of study, the subject of autism becomes my compass and my vantage point—a guide and map with a baseline set of challenges and assumptions. As a performer-designer-researcher and actor in the Bourdieuian sense, I attempt to empathize with the community I work with, to see like they might see, in order to construct an experience for their benefit. This then evolves the bias of my own lived experience.

I have personally seen the impact social stigma has had on my sister's quality of life and the lives of others with disabilities. The common stereotype that a person with disabilities is a defective person persists throughout the language of learning sciences and special education research, as much as the concept is refuted in the field of disability studies. Bourdieu's concept of 'habitus' best characterizes why limiting, deficit-based thinking is still firmly embedded in special education culture. The goal of this discourse is to use this awareness to depart from deficit frames and turn towards a phenomenological one that aids learning design. Together, the turn and the frame serve as a pivot into an avant-garde break from more traditional approaches to special education.

Infusing a media practice within special education. Entering the Media Arts and Sciences program six years ago, I had very limited knowledge of how special education classrooms worked. I started observing multiple classrooms, spending full days with teacher and students, occasionally joining in their activities. In the process, I got to know them, gaining greater insight into their lives and personalities.

A common feature of the classroom included both group and individual daily schedules that were fully planned by the teacher. The teacher used a hanging chart system with color codes representing each student. These codes served to let students know which tasks were assigned to them. Each task—such as cleaning the desk, going to lunch, or erasing the board—had a unique, laminated picture card associated with it, which had icons and printed words and a Velcro patch on the back. Charts full of these cards were hung throughout the room, serving to remind everyone about the sequence of tasks. As students completed each task, he or she would remove the card from the chart and place it in a box to indicate completion.

At the end of the day, students were evaluated based on the extent to which they completed their tasks. Throughout the day, teachers helped students fill out running checklist to mark their progress. The checklist contained their list of tasks and an adjacent box for points, where teachers would write between 0–3 points as an assessment of the quality of their work. A task done correctly and on time, without disruptive behavior, would get the full 3 points. If student-initiated distractions presented themselves during the task, points would be consequently removed. Points were finally tallied in the final period of class, with a minimum total of 10 points earning them a red chip at the end of the day. At the end of the school week, a student who earned a designated number of red chips could then exchange them for a tangible reward, such as money or a special snack. Through my observations, the token economy system seemed to work well in helping students manage their own behavior within the classroom framework.

Although students seemed to be compliant, cooperative, and generally complacent in this highly structured environment, I noticed that these students did not socially interact. In speaking with the teachers, we discussed how social interaction and communication with peers were important aspects of learning that were more difficult for students to practice in the given structure. To use a token reward[4] system to motivate social interaction might result in what Scot Danforth (in Gabel, 2006, pp. 85-102) discusses as the danger of encouraging students to practice skills in an irrelevant context. If interacting with another person was exclusively motivated by external rewards, intrinsic motivation is undermined in what classical behaviorism teaches:

[4] Token economies—where people receive small tokens like discs, chips, or stickers, etc. for compliant behavior, which can then be exchanged for tangible rewards—is a commonly used strategy to manage classroom behavior (Kazdin & Bootzin, 1972; Matson & Biosjoli, 2009). A common problem with token economies in education is that students come to rely on external stimuli and rewards to complete their work, which has the adverse affect of extinguishing internal motivation.

that skills built from gaining tangible rewards become extinguished once incentive is removed. Students would need to find that conversational practice with other students, in and of itself, is internally motivating. For this to occur, a learning design for youth with autism must foreground the student, and not simply completion of the task alone. So I sought to approach learning design with an alternative strategy—one that removed the token economy and leaned on digital media to provide externally motivating factors for participation.

In the next section, I use Bourdieu's thinking tools to deconstruct and problematize the learning opportunities for youth who are taught in this context. Ihde's phenomenological frame is then interleaved with Bourdieu's to attempt an avant-garde shift in thinking that allows us to consider a phenomenological model of speech learning.

Habitus in Special Education

This section places the field of special education under a critical lens, as a way to understand the nature of habits, dispositions, and pedagogy that has grown within this environment. It then applies phenomenological tools to shift how we might think about the field, so that curriculum design can move away from a clinical approach towards an aesthetic one. Figure 1 illustrates this shift in three steps, by first Bourdieu's field theory as it applies to special education, weaving it with Ihde's perspective on noema (Ihde, 2007, pp. 37-40), and then applying this new theoretical fabric towards the design of new pedagogy and technology.

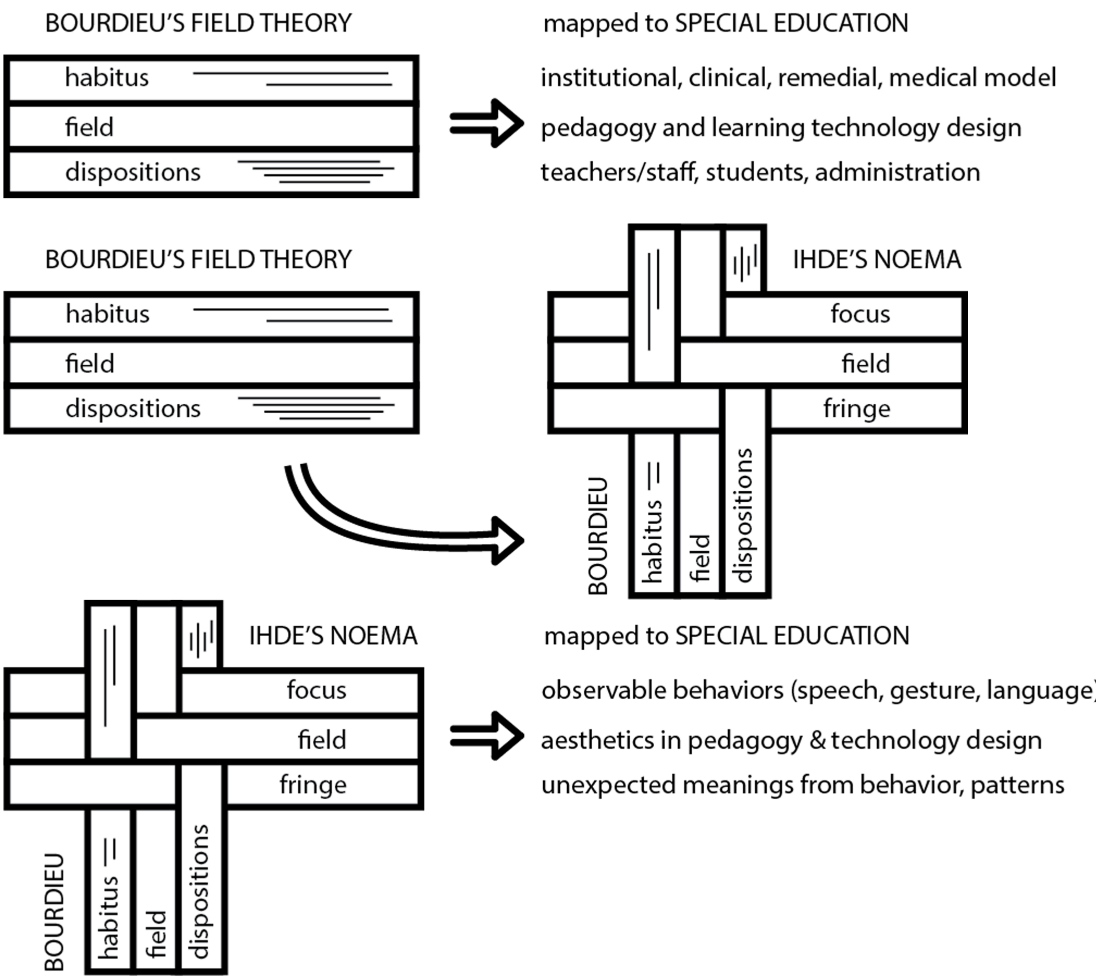

***Figure 1*. Transforming special education. This model describes the state of special education, showing in three steps (top to bottom) how critical theory and phenomenology can intertwine to help shift perspective in a given field.**

Special education and the self-contained classroom. Special education programs are designated to handle students who are seen as unfit or unable to participate in regular subject-based classroom instruction. Self-contained classrooms are set aside to teach students who are most severely impacted by impairments related to their diagnosis. Such students typically spend their full school day in rooms, which can consist of a primary homeroom teacher, a set of activities for practicing functional behavior, and up to a dozen peers who may have similar functioning difficulties. Self-contained programs follow an alternative set of state standards based on life skills learning and are designed to provide further individualized instruction by defining objectives based on students' clinical diagnoses.

The compound effect of individuation in these classrooms sets up the environment to be one that potentially isolates its students from rich interactive and sociocultural experiences by removing them from their typically developing peers and common subject-based curriculum, with the possible result of isolating students from their own classroom peers. The classroom itself is a *structuring structure* (Bourdieu, 1977, p. 72) that reinforces patterns of recurring behaviors. Actors, or persons within this structure (such as teachers, staff, and students), come to embody *dispositions* that influence all activities and responses in the micro-culture of the given environment. Over time, their actions and dispositions acclimatize into a *habitus* that reciprocally characterizes and is characterized by the frame and shape of the environment (Grenfell, 2003).

Institutionalization at the historical root of special education. The segregating nature of special education programs is not unique to education. The institutionalization of people with disabilities has cultural roots in 19th-century America. Starting in the late 1800s, efforts to keep persons with disabilities out of public view were common in the United States (Snyder & Mitchell, 2006). As more people migrated to cities and job competition increased, a stigma towards people with physical deformities developed, causing many to start working on the streets as beggars. The eugenics movement was still popular at the time and permeated into social thinking and scientific research (Snyder & Mitchell, 2006).

Local health and aesthetic campaigns that focused on keeping cities "beautiful" (Schweik, 2010, p. 70) led to public policies that banned anyone who appeared to be beggarly, "ugly," or "unsightly" in a growing trend that spread through railroad lines into major U.S. cities (Schweik, 2010, pp. 23–24). Beggars, peddlers, or disabled people, including those who lost limbs in industrial work accidents or wars, were ordered to remain inside their homes at all times or risk being put in jail. As jails quickly filled up, new facilities that began as almshouses were created to temporarily receive the overflow with two goals in mind: contain excess prisoners while rehabilitating others. Eventually, though, these institutions became functional mechanisms for city planning by serving as terminal locations for disabled residents, where disability could be tightly managed and permanently concealed (Schweik, 2010, p. 77).

The ugly laws served as educational blueprints for identifying and removing children with disabilities from American society. Throughout the 1950s and 1960s, young individuals with perceptible disabilities were required to stay home and out of public view, or risk identification at school. Schools maintained constant surveillance over all students to determine which ones were "unfit to learn," to ready them for mental institutions (Snyder & Mitchell, 2006). Abuse, neglect, and resident mistreatment by the working staff were common[5] within these institutions, which served as human warehouses for hiding people with disabilities.

Throughout the decade following the Civil Rights movement of the 1960s, advocates and parents of people with disabilities mobilized on behalf of all children, of all abilities, for the right to attend school and receive a free and appropriate education. This resulted in passage of the Public Law 94–142 (*Education of All Handicapped Children Act*) of 1975, which has since evolved into the IDEA in existence today. During the 1970s, the federal government also established the field of special education to generate a body of knowledge from evidence-based practices that would help guide curriculum development. Since then, educational research methodologies such as single-subject and multiple-baseline design have been established to reflect the unique needs for studying within the field.

Behavioral psychology's role in establishing that youth with autism could learn. Behaviorally based research has dominated the field of autism research. Behavioral psychology's original efforts by Skinner and Ferster (Ferster & Perrott, 1968; Ferster & Skinner, 1957) provided an initial behaviorally based framework that early teachers and clinicians used to demonstrate that children with autism could indeed learn. In 1988, Wolery published an extensive teaching manual of principles and procedures for using applied behavioral analysis techniques with students with disabilities. The text advocates for behaviorally based strategies and discusses topics such as writing effective objectives, benefits of using token economies, using peers to

[5] Mark R. Lyons' feature length documentary *Lest We Forget: Silent Voices* (2007) compiles footage from these institutions with primary accounts from former residents and their families.

facilitate behavior change, techniques for self-management, and methods of conducting research. Today, clinical methodologies such as Applied Behavioral Analysis, Positive Behavioral Training, Discrete Trial Training, and Pivotal Response Training (Koegel & Koegel, 2006) are well regarded as evidence-based practices for youth with autism.

A firm knowledge base on behavioral management exists and both teachers and students can benefit from these structures with respect to the delivery and acquisition of content. However, many with autism who graduate from secondary education are still unable to make the critical transitions necessary to manage life outside of the school structure. These individuals' internal capacities to draw on skills for self-management, expressive communication, and social engagement in environments outside of the classroom are not being thoroughly developed. Bourdieu's theory of habitus, which I elaborate on next, may help us understand how and why fully managed teaching strategies may contribute to this condition.

Borudieu's Theory of habitus. Bourdieu's (1972) concept of *habitus* is defined as follows:

> [t]he product of history, produces individual and collective practices, and hence history, in accordance with the schemes engendered by history. The system of dispositions – a past which survives in the present and tends to perpetuate itself into the future by making itself present in practices structured according to its principles, an internal law relaying the continuous exercise of the law of external necessities is the principle of the continuity and regularity which objectivism discerns in the social world without being able to give them a rational basis. (p. 82)

Habitus is a thinking tool for examining the situated context around a social system shaped by a history of practices. Practices in a given system influence, and have been influenced by, the existing social system and the actors (persons) who are part of it. The social system works at an unconscious level to impact how actors think and how people are compelled to act. Furthermore, the quality of interpersonal interactions quietly unfold from social conditions that play into the "harmony of aesthetic tastes or ethical learnings" associated with a social structure (Bourdieu 1972, p. 82). Bourdieu observed aesthetic tastes within social conditions, which suggested that an implicit aesthetic affects the broad spectrum of choices that actors make. The aesthetic of the special education system could be characterized as one of functional efficiency and behavioral management that is sanctioned and governed by clinical recommendations and institutionalized rule sets. It could very well be that the prescriptive, regimented, and stigmatic context under which special education was born still causes its actors to self-impose limits on the choice of methods, tasks, language, design, presentation, and protocols of engagement they embed throughout the learning environment.

Examining the aesthetics of disability and of instructional design. Parrish (2008) has investigated and applied aesthetics to education to affirm his position that instructional design is first, and foremost, a design discipline. In other words, the aesthetic qualities of learning design have direct bearing on student learning. Parrish's view on aesthetics is drawn from Dewey's (1934) pragmatic definition of aesthetics as a category of experience that is immersive and meaningful. He likens the value of aesthetics in this sense to works of art that prime us for learning by "challenging us to see the world freshly, to become open and responsive to possibilities in the world around us" (Parrish, 2009, p. 5). This has significant implications for the ways in which special education materials and curricula are designed.

From my experience, visiting multiple special education programs, a typical classroom setting is populated with materials that are primarily functional (such as laminated picture cards with Velcro and binders), procedural (as in lists of activities, matrices of chores, workbooks with sequentially numbered tasks), and targeted toward a younger demographic (e.g., coloring books, picture cards with cartoon faces). Social skills activities have included the use of soft colored balls that can be tossed, exchanged, and shared across multiple participants. These items seem to work well in getting students to follow their designated schedules and tasks, even at the high school level. However, as a mode of classroom management, these materials may unconsciously reinforce the notion that individuals in special education cannot appreciate a more aesthetically rich or complex environment. The difference in classroom aesthetics is most dramatic when compared with rooms where standard subjects such as science, math, or art are taught.

Disability studies scholar, Susan Gabel, explores the concept of *an aesthetic of disability* in an attempt to step out of, and beyond, purely medical-deficit or social models of disability. She proposes that "aesthetization" is how one may come to know something, and that experiencing disability through an aesthetic discourse allows for flexibility, "opening up the possibilities of the disabled body, and the ways in which disability discourses of self and community craft narratives of the art of experience” (Gabel, 2006, p. 22). Examining disability from an aesthetic perspective allows “movement all around and inside disability” by subverting dominant aesthetics and refuting hegemony as it “creates spaces for interpretation that might not be available without the aesthetic framework” (Gabel, 2006, p. 12).

An awareness and attention to aesthetics in special education has the potential to transform pedagogy and educational access for youth with disabilities—particularly, those whose daily schedule is exclusively limited to learning in the self-contained classroom. Because students’ cultural experiences at school remain separate from the rest of campus, the habitus in these locations may be particularly strong. This further motivates the creation of learning designs that incorporate what Gabel (2006) calls resistance, counter-hegemonic, or subversive aesthetics (Gabel, 2006, p. 34) to counteract the dominating effects of the deficit-based structures of special education.

Bourdieu and the avant-garde for instantiating change in a field. One concern is that introducing new technologies or approaches to learning may encounter forms of resistance from teachers and students. Another concern is that actors may inadvertently re-appropriate new tools and suggestions in ways that reassert the very paradigms they sought to change. Reay (2004, p. 437) argues that habitus does not lead to determinism, but rather, it can work against individuals’ struggles to change his or her world.

Grenfell & James (2004) regards educational research as a field by following Bourdieu’s position that any field is also 'bounded' by that which it includes or excludes “constituted by all that is methodologically possible within it” and “the range of research activity and the principles that guide it” (p. 510). They introduce research-fields as temporal and subjective to generations of trends, which is important in understanding mechanisms of change within the field. Grenfell & James then describe how the use of an avant-garde to challenge the status quo is consistent with Bourdieu’s position on change, and that eventually, “one avant-garde displaces a previous avant-garde,” such that over time, “it will become acknowledged, established as a consecrated avant-garde, and then pass into rear-garde position” (2004, p. 510).

Although the work presented here may not result in immediate and clear changes to the way in which special education uses technology in learning environments, it provides a seed for future change. A learning experience in an alternative environment may catalyze change in the habitus if the experience is strong enough to provide actors with new ways of perceiving themselves and each other. Furthermore, by refocusing on the strengths of autism as a disposition, a new vision for learning opportunities can grow based on the qualities, strengths, and desires of the individual. In the next section, autism is discussed and explored in this way to create working links between clinical autism research and the lived experiences of individuals with autism.

Using Phenomenology to Expand the Field

The field of HCI has the potential to expand the kinds of learning possibilities that are currently outside of special education's reach, offering alternative methodologies of research, vision for technology, and experiential focus as it pertains to the human condition. Ihde's (2007) approach to *field* can help make this link for special education in two distinct ways. First, Ihde's understanding invites an opportunity to move Bourdieu's position on *field* out of a state of examination and into one of design. Ihde's *core-horizon* structure (2007, p. 39) proposes that what we are trying to observe—the *focal core* of our interest—primes us for an awareness of what is at the *fringe* of our experience, i.e., those things that we did not initially seek to observe. By scanning the horizon for these fringe events, we catch a glimpse of what is just beyond observation, or invisible, due to the limits of our own vision. To view another person or context in this way is to give them an opportunity to challenge what we know about them. Thus, to construct an immersive media experience that allows individuals to share of themselves freely, in a language that they would choose, without a pretext for controlling their expression, expands our knowledge by giving us a window into their world.

Autism as a disposition. Leo Kanner published the paper "Autistic Disturbances of Affective Contact," using the word *autism* to describe eleven children he observed to be self-satisfied (Kanner, 1943). If we take the primary disposition of a child with autism to be that of preferring autonomy, in being alone, then the major learning design task is to stage an authentic encounter with another that motivates that child's desire to strengthen his or her relationship with another. To keep the child's agency in tact, the learning task must cultivate the child's self-motivation and result in an inner reward based on a meaningful awareness of being *in-relation-to* another person.

A focused interaction with another person first entails an awareness of oneself, followed by some degree of clarity about the existing or potential connection with another. For people with autism, who are often said to 'think in pictures,' the abstract notion of connecting with another human being may be entirely elusive because the spoken word is invisible and leaves no physical trace. Temple Grandin, an animal scientist and person with autism, found that people with autism thought in three primary ways—through visual thinking, pattern thinking, and/or music-math thinking (Grandin, 2010). Indeed, many successful tools and alternative communication devices for youth with autism, such as the Picture Exchange Communication System (PECS) (Bondy & Frost, 2001), involve the use of pictures or visual aids to supplement learning and structure. The TEACCH method (University of North Carolina at Chapel Hill, 2013) specifically helps teachers create a classroom-based infrastructure of visual schedules and physical locations, which provide logical, cognitive aids that help students internally manage and organize their days.

Autism and the usefulness of visual representations. Temple Grandin's autobiographical account *Thinking in Pictures* (1995) relates how concrete metaphors, such as a house with doors, stairs, and windows, helped her focus and stay motivated as she progressed in her academic and professional career. The visual metaphor became a guidepost on which she could lean on to map difficult, abstract, concepts on something concrete. If metaphors were consciously integrated as a pedagogy technique to help motivate youth with autism to learn, metaphors might then be strengthened and made visually real with a virtual environment and/or through digital projection. In this kind of mediated environment, visual metaphors could be designed into a dynamic image display that is spatially mapped and projected onto physical elements such as a board, actual people, or classroom features.

Managing sensory overload. Individuals with autism often have difficulty managing multiple modes of stimulus in an environment, with sensory reactivity varying for each individual

(Greenspan and Wieder, 2009, pp. 149–159). As with any tool, the integration of multi-sensory feedback will have a direct impact on how a person with autism experiences it. Just as adjustments and modifications must be made to a physical environment to allow students to manage, an immersive media environment must develop strategies for delivering optimal feedback. Greenspan and Wieder (2009) offer principles that are common for addressing sensory challenges, such as using other senses "to create the awareness and understanding of the world that ordinarily would occur through the impaired channel," and getting "all the available senses working together as a team" (p. 149). Coupling modal feedback is one method that may reduce cognitive overload if a person has trouble parsing auditory and visual feedback separately. This technique may offer clarity by amplifying the experience of an event via reinforcement through multiple modalities. This link, first made in the environment, then becomes part of the internal experience of Andy Clark's hypothesis, that when parts of the environment are coupled to the brain in the right way, they become parts of the mind (Clark, 2011). The link then provides a building block for future experiences, which together act as alternative pathways or scaffolds to learning (Vygotsky, 1978, p. 84). I discuss the nature of this kind of scaffolding in the next section.

A Phenomenological Model for Speech-Based Interaction

In this section, a theory of learning is built from the perspective of autism as a disposition that leans towards visual and pattern-based thinking. Figure 2 presents a diagram of how rigid protocols and procedures of the special education environment may be reinforcing static thinking in youth with autism. The heavily structured environment works to calcify pre-existing multisensory barriers that prevent these youth from experiencing and adapting to the fluid and dynamic nature of vocalization, sound processing, and listening.

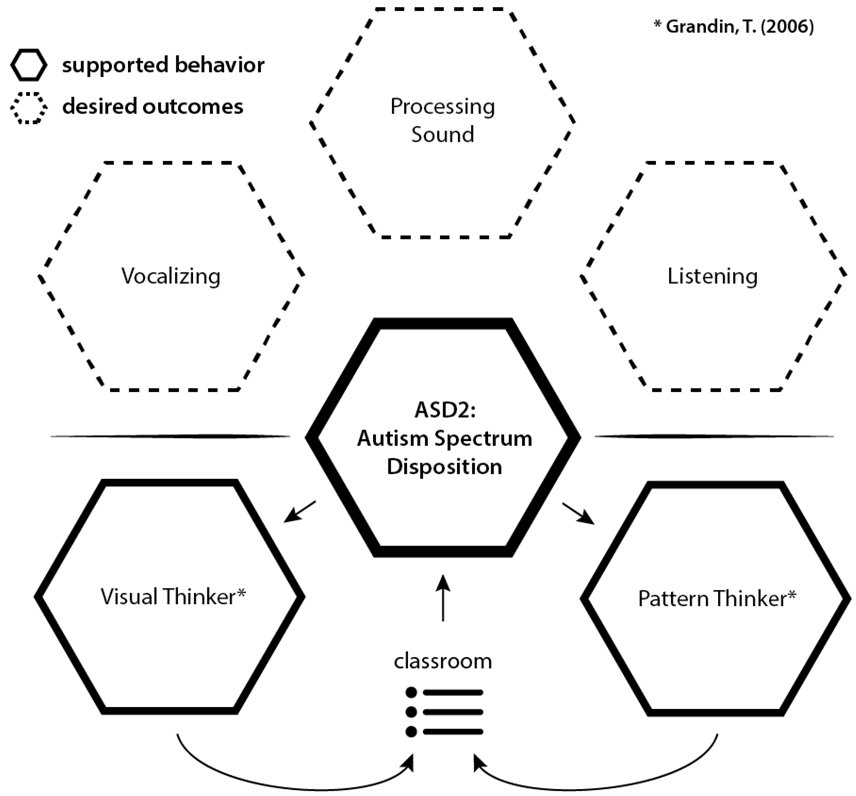

***Figure 2*. Autism as a disposition. Persons with autism often think in visual patterns and logic (Grandin, 1995), which are reinforced by static classroom procedures and protocols. This creates an implicit barrier, preventing visual strengths from crossing over to support auditory and vocal types of expression, which are more dynamic in structure.**

The section develops the concept of inner speech to develop a new kind of phenomenological learning model, presented in Figure 3, which draws on the affordances of immersive media to provide a visually grounded experience of speech and sound. Through this model, youth with autism learn to use their voice to generate a mediated experience that provides a visual kind of inner speech – an inner picture, which I describe below. This inner picture is an internal tool, learned and retained by individuals who participate in the experience, to remind them of what it means to speak, to listen, and to imagine that they can use their speech to make meaning in an embodied and visually vivid way.

From inner speech to inner picture. Ihde (2007) describes the nature of inner speech as having speeds and modulation, as it “bursts forth in rapid totalities that present themselves as an uneven ‘flow,’” where “a larger ‘singing’ of phrases and sentences” takes precedence over any actual words (p. 140). Dynamic media can be thought of as a corollary to the fleeting nature of voice. Ihde remarks that inner speech (which is different from the kind of external, typical speech we produce with our mouths) tends to race inside a person (2007, p.140). Some people with autism speak in bursts of rapid speech, including a participant in this study. If we imagine that the inner speech of youth with autism might be racing in this way, it seems possible to draw vocal expression out using media may draw attention to speech in a different way, thereby slowing it down externally as a way to help slow speech down internally.

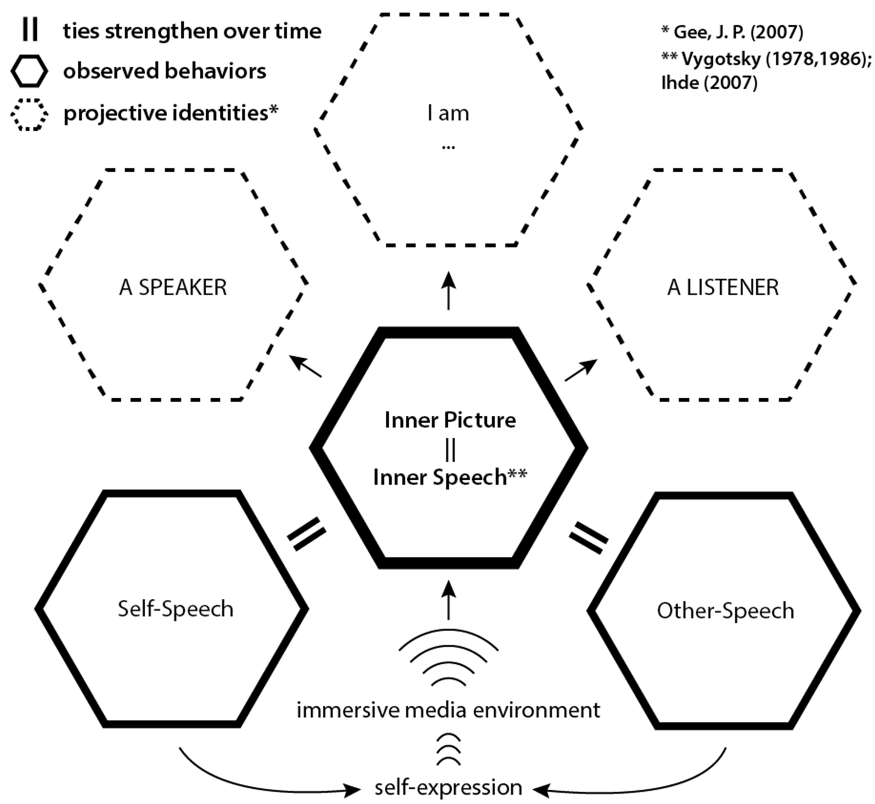

***Figure 3*. A phenomenological model for speech learning, based on a projective feedback loop. Being immersed in one's own voice as it gets translated into environmental feedback reinforces the simultaneous seeing and hearing of one's voice, which strengthens a person's inner picture/inner speech about what it means to speak and be heard.**

Drawing a parallel between media and the bursts and singing of words, a projected image of many visual particles pulsing rapidly and unevenly metaphorically mimics simple utterances. Dynamic media can paint a picture of one's voice by providing immediate feedback that supports a free form, stream-of-consciousness-style vocalization.

Ihde (2007) points out that speech is separate from sight, but that which is auditory is central to inner speech (pp. 143–4). For youth with autism, making this visual-auditory link to speech is critical because it may connect for them the physiological experience of sound and speech with an inner visual representation of it. To find a way to establish this link may help their proprioception with respect to speech. He further asserts that “the wordless voice is pregnant with significance but not yet word” (2007, p. 154) and goes on to support a general practice of the voice, from which words will eventually form. This is common to rehearsal practice of any kind, and especially vocal music, where the warming up of muscles associated with the voice helps the vocalist become more fluid over time.

From inner picture to projective identities. As inner speech or inner pictures form over time, a child comes to define for him or herself what is taking place. As the individual’s internal representation of the phenomenon matures, that representation provides a meta-structure, a scaffold, an inner picture for what exactly he or she is doing. In applying this concept to youth with autism, who rely on visual cues for communication but have difficulty parsing verbal or auditory ones, the experience of seeing and hearing the invisible voice resonate through the body and into the environment, provides this kind of *inner picture* of their voice. This picture, which a person co-creates with the environment, becomes an internal tool that the participant can re-imagine in his or her mind when it comes time to speak again.

As a tool, the inner picture is an artifact of a person’s projective identity. In other words, if a person sees himself in this newly extended way and desires or relishes in this extension, then the person adopts this hybrid, augmented sense of himself. Because the person is also conveniently the character in the alternative environment, the projection remains with the person, helping to reinforce the vocal aspect of that person’s identity.

Self-development as involving an inner picture in-relation-to others. From a sociocultural perspective, the context for students in a pair-based activity enables them to further solidify an inner picture about an interpersonal experience.

> Language and thinking are tied to people’s experiences of situated action in the material and social world. Furthermore, these experiences are stored in the mind/brain not in terms of language (‘propositions’) but in something like dynamic images tied to

> perceptions both of the world and of our own bodies, internal states, and feelings. Increasing evidence suggests that perceptual simulation is indeed central to comprehension. (Barsalou, 1999, p. 74)

Learning is situated. *Situated cognition studies* refers to a collection of viewpoints that believes "thinking is connected to, and changes, across, actual situations and is not usually a process of applying abstract generalizations, definitions, or rules," or that "language is tied to *people's experiences of situated action in the material and social world.* Furthermore, these experiences are stored in the mind/brain not in terms of language, but in something like dynamic images tied to perception both of the world and of our own bodies, internal states, and feelings" (Gee, 2008b, p. 90).

A model of projective identity pre-supposes that a person desires to link his or her self-concept to a greater vision of oneself, and that this in its own right becomes the catalyst for intrinsic motivation. As a student demonstrates potential, the potential for himself, as well as others, surpasses his own expectations to grow and reinforce his self-concept. Child psychologist R. Peter Hobson's (2010) theory on children with autism focuses on the development of self-other relations and "children's emotional relations with embodied persons as foundational for their growing understanding of minds" (p. 391); and it is key to developing their social cognition. Hobson follows Vygotsky's notion that:

> Self-other relations and experience are transformational for cognitive as well as social development, so that symbolic and imaginative activity as well as self-regulation and aspects of executive functioning may draw upon and/or be intimately connected with developments related to the self. (Vygotsky 1962, cited in Hobson, 2010, pp. 399–400)

Vygotsky's perspective is that symbolism, imagination, and self-regulation are critical to self-development and development of relationships with others. Gindis (1999) also reiterates Vygotsky's position that an individual's identity is shaped by socially meaningful activities, and that the "formation of individual consciousness takes place through relations with others" through socially meaningful activities (Gindis, 1999, p. 336). Vygotsky saw the nature of disability as dynamic, that development was not a straight path, that transformations can occur, and that development was mediated by material instruments and social signs; language, culture are acquired through internalization of those signs (Gindis, 1999, p. 336). During Vygotsky's life, however, there were no digital tools that could deliver the kind of instruction he describes. Today, immersive media environments could be designed to use signs and signifiers that bring individuals together in symbolic ways.

Because many individuals with autism already encounter challenges with their own bodies, the problem is compounded in uncontrolled environments where they must adapt to competing multisensory inputs. The complexity of physical spaces and social dynamics in everyday classrooms poses a learning contradiction for students with autism: students must learn to learn in an environment that is suboptimal for their learning. This situation begs for an environmental solution—one that cohesively unifies the person's sensory experience with how he or she experiences peers, so that a learner can perceive that there *is* an opportunity to learn, and then successfully act upon it (Gee, 2008a, p. 82). The environment must offer these individuals what Gibson (1979) and Norman (1988/2002) refer to as *affordances* or *action possibilities*.

An ideal learning situation will occur in a context that integrates the presence of human bodies and symbols into an affective and embodied experience. The context will activate each student's imagination about the other—for example, highlighting features of their actions, characteristics, or personalities—to give them agency to be actors and co-creators in generating the imaginary space. A situated/sociocultural theory of learning supports this style of learning, as it "looks at knowledge and learning in terms of a relationship between an individual with both a mind and a body and an environment in which the individual thinks, feels, acts, and interacts," (Gee, 2008a, p. 81) by foregrounding the body and the environment. Dourish (2004) further echoes this aspect of human action in relation to technological design:

> Embodied interaction is not a technology or a set of rules. It is a perspective on the relationship between people and systems…. The question is not whether this or that technological facility will be available to us; the question is how we will be able to understand it, control it, interact with it, and incorporate it, into our lives. (pp. 192-3)

Learning transfers as the persistence of somatic memory and social triggers. In an immersive media environment, a student can test his or her voice in an open and alternative setting, to decide if what he or she experiences is worth trying again. If so, a student continues to experiment, a rehearsal process that will eventually develop a sense of agency and control. Once that agency and control is firmly established, then the student internalizes and absorbs that experience somatically. The experience of the feedback loop grows and reinforces the inner speech/inner picture, which then allows the student to transfer his or her learning back into other contexts. Because a student's peer is built into the experience, the added benefit of seeing that student in class is yet another trigger that reminds the student of the experience they shared in the alternate context. They can look to each other as reminders of what it meant to speak in a shared context.

Speech is no longer tied to a script or a fixed protocol. It is no longer a classroom task on which to be assessed or evaluated. It is an inherent skill, an option for self-expression and connecting with others that one can choose to exercise. Speech is appreciated and valued because it has been seen. A media environment that can audio-visually symbolize aspects of communication and relationships then becomes a scaffold for triggering growth within the child's zone of proximal development (Vygotsky, 1978, p. 86), allowing him or her to develop stronger reasons or roles for practicing communication. They may start their practice by vocalizing, and then verbalizing, both of which are acknowledged and transmuted through dynamically generated media, to be seen and heard before becoming internalized speech, or "inner speech" (Vygotsky, 1962; Vygotsky, 1978, pp. 25-30).

Strengthening alliances and building trust through novel experiences. An immersive environment that is also novel for youth with autism has the possibility of resonating with the participants (i.e., they embrace it) or over-exciting them such that they refuse to participate in it or are overwhelmed by it and tune out. One common coping mechanism, repetitive behaviors, is a core characteristic of autism. Another more constructive coping strategy is that an individual would seek out an anchor in something or someone familiar—for example, the teacher, an expression, or a peer. In this way, an alternative space that seeks to push participants somewhat outside of their comfort zone may heighten that person's awareness, compelling them to engage, and effectually, priming them for a moment to learn. This offers a crucial moment for relating, whereby a teacher or peer can step in just in time to create a moment for teaching, learning, or simply sharing the experience of discovering the new environment together and strengthening their alliance.

Making visible that which is not. In 2008, colleagues and I performed a study on teaching the chemistry concept of titration at the molecular level (Tolentino, Birchfield, Megowan-Romanowicz, Johnson-Glenberg, Kelliher, & Martinez, 2009b). The goal of the study was to make visible a chemical process that is otherwise invisible. A high school chemistry class used a learning experience in SMALLab to help students make connections between stoichiometric formulas and the instantaneous color change of a solution. Chemical reactions at the molecular level are not perceivable by the naked eye. The learning experience was designed as a special lab for exploring molecular reactions. Molecule types, ionic bonds, and moments of titration were highlighted using color, shape, sound, and text. The study revealed that students who had trouble making these connections through standard classroom curricula were able to demonstrate significant gains in understanding, both in multiple choice and written responses, after SMALLab. An analysis of their discourse also found that specific design features, such as color and sound, provided anchors for helping them discuss and construct their final mental models.

The relevance of this experience to the concept of projective identity is that students began to participant in ways that characterized young scientists. On their own, they modeled inquiry learning for each other by asking questions, testing their hypotheses, and iterating over the process. The overall learning experience, supported by the environment and teacher guidance, was aesthetically matched to the kinds of interactions that a young scientist would have if they were faced with a lab-like space. However, the design featured physical, embodied actions that expanded their learning from abstract to direct engagement on a clarified set of actions. This provided an experience that was immersive enough for students to walk away with a somatic residue of experience—one that persisted and transferred back into the classroom.

CHAPTER 3

Embedding the Voice in Immersive Media Contexts

Chapter 2 introduced a theoretical framework for thinking critically about the habits and aesthetics of teaching and learning within special education environments and the specific implications for supporting communication skills for youth with autism. This chapter discusses how immersive media environments offer a new solution for learning design because of its unique affordances, which include fully programmable media and the potential to situate people into a mediated context where projective identities can take root. This chapter presents a conceptual framework for the design of *Sea of Signs*, an immersive media experience made to reinforce self-expression in youth with autism. The first section, “Why we should care about embodiment,” sets up the relationship between embodiment and the voice, elaborating on Don Ihde’s work with Andy Clark’s notion of the extended mind. A set of design heuristics are presented based on a series of pilot studies conducted using the SMALLab in special education.

Why Embodiment Matters

The body stands at the core of disability studies, phenomenology, and human-computer interaction. This section takes a brief tour of the discourse to motivate the context for extending embodiment discourse to include the voice.

Expanding embodiment in disability studies through phenomenology. For people with disabilities, the medical model continues to dominate discourse around the body. The medical model defines disability as a problem or health condition of an individual. From this perspective, the problem requires treatment, management, adjustment, or behavioral change to cure the perceived problem. B. Turner (2001) points out, however, that this view does not consider “the subjective worldview of patients as constitutive of the condition and does not recognize the role of politics and culture in shaping human suffering” (p. 257). A social model of disability was developed in response to the medical model, refuting the notion that disability is an individual’s problem. In this model, disability is a function of systemic barriers and attitudes that have socially isolated and oppressed persons with impairments by restricting their self-determination and excluding them from opportunities to participate (Oliver & Sapey, 1983). This stance has allowed people to mobilize as a distinct social group to receive specialized services. However, it has also created and reinforced barriers by segregating people with disabilities.

For example, Shea and Mesibov use the concept of the "culture of autism"[6] to foreground similarities they identify across people with autism. The goal of foregrounding autism in this way is to develop concrete approaches for teaching individuals with autism to adapt and function within pre-existing social norms. However, Ferguson highlights a tension stemming from the assumption that, with all barriers removed, persons with disabilities are "essentially the same as everyone else," and should therefore aspire to assimilate to social dimensions to receive the acceptance they deserve as full citizens (2003, p. 143). The tension is that labeling or essentializing a person as a member of some community, based on perceived characteristics, imposes limits on our understanding of that person. The root of the tension is primarily social, because the ways in which persons with significant disabilities are heard and seen depends on who is listening and watching, and in what cultural context (Ferguson, 2003, p. 136). Only the individual can truly claim to know his or her lived experience.

Disability scholars Paterson and Hughes (1999) argue that the social model of disability, however, presents a "disembodied view of disability" (p. 597) by removing the body from disability discourse. To bring the body back into the discourse, both scholars propose a sociology of impairment (Hughes & Paterson, 1997), which can then open a more "radical phenomenological approach to the (impaired) body" (Paterson & Hughes, 1999, p. 597). To understand embodiment, we cannot deny the distinct and different ways in which people with autism might think, feel, or act as a result of their sensory experience. We also cannot ignore each person as an individual shaped by the unique set of his or her lived experiences.

Reconciling embodied cognition with culture. With the medical model continuing to dominate embodiment discourse for people with disabilities, the clinical, functional, and in ways, sterile aesthetic of special education still persists. Addressed by Ferguson (2003), the effect of

[6] Gary B. Mesibov and Victoria Shea's concept of the "culture of autism" is composed of a list of thinking difficulties and strengths for guiding teaching and classroom design for individuals with autism. http://www.autismuk.com/?page_id=104, accessed on April 7, 2013.

the medical lens presents another problem. Individuals with profound cognitive disabilities are then seen as having no culture—that is, no meaning in behavior, “words but no discourse,” “events but no story,” and simply “a single person in a cultural void, as close to a de-contextualized existence as possible” (p. 135). Cheville (2005) illustrates how the discourse on embodiment is not exclusively cognitive, but in fact, culturally intertwined.

In an ethnographic study of athletic learning of a women’s intercollegiate basketball team, Cheville (2005) explored how the body exists as a cultural construct. The study included twelve female subjects situated at the intersection of multiple cultural gazes: as women athletes, as African-Americans (for some), they engaged in a highly physical activity of asymmetric relations that included teacher, player, novice, and expert. As they played basketball together, they emerged as a collective team, requiring their physical presence in an “orchestration of bodily activity” which allowed them to enter into a “reflexive consciousness” (p. 98). Cheville claims it is this “recurring physical experience of being ‘inside’ and ‘outside’ culturally codified boundaries that shapes an individual’s abstract, or non-physical, understanding of herself as actor or audience, accepted or negated, insider or outsider” (2005, p. 99).

Cheville’s (2005) study has relevance in contextualizing an immersive media learning experience for youth with autism who have been in special education most of their lives. Just as the basketball players have a sociocultural and historical context, young individuals with autism also have and inhabit multiple contexts that they bring to any learning experience. However, their history alone does not circumscribe who they are or what they are capable of. They also share in a unique learning experience together, one that harbors the potential to bring about a reflexive consciousness within them. The primary insight Cheville offers disability studies is that a theory of embodied cognition must account for “the human body as at once an object of culture and a subject of cognition” (2005, p. 87). As human beings, our conception and treatment of our own bodies is impacted as much by our histories as it is by the immediate activities we are engaged in.

Embodiment as presence, agency, and the quality of immersion. It is a tautology that every human being has a body. However, the extent to which a person feels or is aware of the presence of that body, or some aspect of it, may be fluid. My assertion is that experiencing a sense of presence is necessary to engage meaningfully in any activity. Presence is a result of a combination of two factors: first, the quality of immersion within an experience, and second, the degree to which one feels he or she has agency within the experience.

Immersion is not a purely passive act of having the physical body placed or located within some physical environment. Rather, immersion involves a state of awareness whereby the raw materials from which an environment is constructed (such as gear, fixtures, equipment, sounds) perceptually recede into the background as an aesthetic experience comes into the foreground. John Dewey (1934/2005) describes the perception of an aesthetic experience as “an act of the going-out of energy in order to receive,” one that “proceeds by waves that extend serially,” where the scene is “emotionally pervaded throughout” (p. 55).

For example, one who watches a friend play a video game may be following the story line or in the shared activity of hanging out with a friend. However, the person who actually plays the game may be experiencing the story in a deeper, multi-layered way. The person playing the game is immersed in two dramas, the first of which takes place in a virtual world. In this role, the game player is an actor embedded into the narrative that takes place onscreen, where the player has the agency to make choices that impact the game. The second role involves a meta-performance for the friend, who sits next to the player, watching and perhaps cheering the game player on. For the game player, the stakes are higher because of a dual-layered immersion that results in the presence of another person also witnessing the performance.

Agency refers to the perception of an opportunity to act, and the capacity to perform that act. Having agency comes about by way of perceiving what J.J. Gibson (1979) first described as an affordance, or "an action possibility available in the environment to an individual, independent of the individual's ability to perceive this possibility" (McGrenere and Ho, 2000, p. 179). In other words, awareness of an affordance is a prerequisite to agency. When an actor both chooses and is able to produce reliable outcome in a given environment, he or she has agency in that environment. The extent to which the actor’s intention and expectations are matched by the outcome describes the actor’s degree of agency. Furthermore, to be embodied means that witnessing an action mapped to some feedback is not enough; an actor must perceive or associate the mapping with some greater symbolic significance.

Andy Clark's (2003) work on telepresence identifies the human sense of presence (or being in a certain place in space) as fully determined by our ability to enter into closed-loop interactions where an intentional move to sense something yields an awareness of new sensory inputs (p. 207). This is similar to the reflexive, self-discovery process that can occur in the kind of embodied experience I attempt to describe, where one feels a sense of presence that relies on a person's sense of agency and immersion. When that presence is firmly established, it is then possible for the immersed individual to experience a projective identity (Gee, 2007, pp. 49–54).

Exploring Autism, Voice, and Multi-sensory Experiences

The effect of normalizing unique vocal expression. When we act upon something, whether it be it a person, an object, or an environment, we desire some kind of response; and if our expectations do not match the outcome, we become frustrated. Imagine a young teenage boy with autism is trying to express excitement for a new toy truck that arrived in the mail. The last time he was this excited was when he watched his favorite Disney movie, *Aladdin*, two months ago. His emotions are activated in an associative manner, so he shares his excitement by quoting genie from the movie, saying, "Alacadabra, alakazam!" Someone who knows him well and knows he loved the movie might be able to decipher his excitement about something, and then inquire more. However, another person who has neither experience nor a context for understanding such an expression might not respond favorably, e.g., dismissing the expression as childish behavior, correcting it, expressing confusion, or remaining unaffected. In other words, a listener who does not recognize the social, historical, or cultural context of this expression, might feel that he or she cannot relate to the boy speaking. This ultimately means, the boy is not heard.

A capacity for learning multi-sensory patterns and categories. Persons with autism have very different sensory perceptual experiences from those who do not have autism (Bogdashina, 2003). As various modal inputs (such as sound and light) come from one's physical surroundings, they compete in ways that can challenge a person's ability to cope. This should not, however, preclude or even dissuade designers from creating multi-sensory experiences for youth with autism. Cesaroni and Garber (1991) explored two firsthand accounts of high-functioning individuals with autism and identified five salient themes: sensory processing, memory, stereotypical behaviors, social interaction, and empathy. Basing their analysis on participant observations, correspondence, interviews and personal documents, the study found that both participants had capacities for multi-channeled sensory processing and remarkably detailed memory of past events (Cesaroni & Garber, 1991).

Grandin, a self-advocate and well-known scholar with autism, has shared both personal and scientific insights with respect to autism and the brain. In a recent TED talk, (Grandin, 2010) she described three types of thinkers with autism, one being highly visual and another thinking in patterns. She has described the existence of some variability in sensory preferences between people with autism (Grandin, 2009a, 2009b). Grandin has also remarked that people with autism are adept at sorting and placing things into categories, whereas coming up with new categories can be more difficult (Grandin, 2006, p. 28–29). These insights suggest that a learning experience designed to be visually strong, pattern-based, and salient in terms of categorization may be a useful tool for teaching youth with autism.

An immersive learning experience can integrate Grandin's insights using multimodal affordances (e.g., audio, visuals, haptics, tactile feedback, or some combination). Used in this way, an immersive media environment can provide learners with a point of entry into otherwise purely abstract concepts, such as the nature of how a conversation takes place by offering a metaphorical experience that aids with category and concept formation. Feedback could be designed to deliver learning content that emphasizes visual and/or pattern-based thinking. To emphasize pattern-based thinking further expands the learning audience, if we consider connectionist ways of thinking, which posit that human beings are "powerful pattern recognizers" (Gee, 2003, p. 9). Indeed, multiple efforts by media and interaction design researchers support a growing belief in the potential for virtual environments and interactive technologies to support social skills training for youth with autism (Gilette et al., 2007; Moore et al., 2005; Parsons et al., 2004).

Visual media in autism intervention strategies. Research in autism has found that social and communication skills can be developed through the use and exchange of visual media. As defined above, PECS is one such picture-based communication strategy used to teach and improve communication for persons with communication difficulties and impairments such as those linked to autism (Frost & Bondy 2001). In this strategy, students pass cards with printed words and pictures back and forth in communication with others. Hart and Banda (2010) reviewed 13 published single-subject studies to examine the effectiveness of PECS, the effects of PECS on speech and problem behaviors, generalization beyond training conditions, and social validity of the intervention. They calculated the percentage of non-overlapping data points for all participants to quantify, compare, and analyze results. Their results suggest that (a) PECS increased functional communication in all but 1 participant, and (b) PECS decreased problem behaviors while increasing speech in some individuals.

Delano (2007) investigated video modeling interventions involving a child watching videotapes of examples of adults, peers, or him- or herself engaging in a behavior that is being taught. Delano reviewed nineteen empirical studies occurring between 1985 and 2005, with most studies using either a peer of adult (i.e., other) as model, or one's self as model. In general, the findings indicated that video modeling interventions were effective in teaching various skills to children with autism with some mixed results. Ultimately, the study found that video modeling "often facilitates rapid skill acquisition, maintenance, and generalization across settings, people, and materials," which the author considered important because generalization is often difficult using basic prompts or live instruction (Delano, 2007, p. 41). The relevant point from this study is that for youth with autism, there is value in having another person as a visual reference for modeling one's own behavior, and that learning using persons in a mediated context (in this case, using video) can persist over time.

MEDIATE (Parés et al., 2004; Parés et al., 2006) is one example of how a multimodal environment designed specifically for youth with autism was able to successfully promote exploration, motivation, and manipulation of abstract forms. This interactive system was designed for children with severe autism and no verbal communication, which challenged designers to approach the creation of an interactive system from which participants could not be typified. They decided on a simple goal: to design a “fun application” with no explicit intention to reach any level of education or therapy. Their desire was to give participants a sense of agency by first providing a sense of control in the interaction dialogue. They introduced visual stimuli that were geometric, abstract, two-dimensional (2D), real-time computer graphics in a full-body, non-invasive, interactive space. Parés et al. (2006) recognized that unique experiences and sensitivities of such individuals’ demands on non-invasive systems and new approaches for real-time generated stimuli must be analyzed and developed to inform new strategies for designing interactive systems for low-functioning children on the autism spectrum.

Embodying the Presence of Voice through Media

Don Ihde (2007) applied phenomenology of sound to the study and exploration of listening and the voice. Ihde’s investigation of sound posits an experiential view of a unit of speech:

> To speak, to understand, and to perceive are meaning-acts. But what is heard, understood, and perceived – within the realm of human being – is also taken as already pregnant with meaning. (Ihde, 2007, p. 148)

If we are to support the growth of self-expression and identity work for youth with autism, it is important to grow the ways in which we examine, support, and frame the context and character of their speech. To listen to what is said is to move past our own judgments of what is appropriate or inappropriate to say, and to provide a more fully empathic response to their words. From a phenomenological perspective, we could listen to the genesis of their voice, ranging from the volume of breath to the depth of a soliloquy, and ultimately, any utterance could be an intention to communicate. Beginning with the most basic unit of the utterance, an immersive media response could simply be to listen for a sound, and then amplify or reinforce it through multimodal means.

I assert that at the core of all human beings is the presence of a physical body and a voice. The body is activated by the breath-voice, pulsing and resonating in an endless cycle of taking in and giving out. The voice of a person can range from a loud scream to a soft hum, and all in between. The significance of locating the voice in the body, as a most basic form of embodiment, is to claim a space for the possible presence and participation of anyone, including those who have lost or possess limited control over their physical limbs. Embodiment, embodied cognition, and embodied design that accounts for the voice provides another entry point into a discourse circumscribed by the mind and the flesh.

Whereas everyone possesses a voice, Ihde sets the stage for an expansion of the voice in his discussion on inner speech, a topic that crosses over into Vygotsky's own position on inner speech. Ihde describes how there are voiceless words, wordless voices, and "the voices of things which are a wordless speaking," such as indecipherable utterances, which are "pregnant with significance but not yet word" (Ihde, 2007, p. 154). For youth with autism, it is this wordless speaking, and the utterances that contain meanings we cannot yet understand, that I seek to extend.

Activating vocal potential by coupling it with responsive feedback. A fully programmable, immersive media environment offers an alternative space for self-expression. It can offer the kind of empathic and flexible response that may not be possible in an everyday context. For a person still learning to speak or become comfortable with his or her own speech, I propose that what he or she desires most is to be heard and acknowledged, without judgment. An immersive media environment that receives vocal input can be tuned and designed to hear a person in this way. Using a microphone to sense the voice, the pitch and frequency spectrum, for example, can be transformed and amplified to create an audio with subtle reverberation and a colorful visual particle display. In this way, the utterance is augmented and extended through the environment, in a way that both clarifies and communicates the spatial and temporal nature of the presence of the voice through an experiential metaphor.

Andy Clark's theory of the extended mind describes the body as "the point at which willed action, if successful, first impacts the wider world" to yield an "intuitive understanding of the body as the common and persisting locus of sensing and action" (Clark , 2011, p. 206–7). When a person performs an intentional vocal act to communicate in a specially designed immersive environment, the media responds with a display that is then seen by the person who spoke. It is through this closed loop of speaking to generate an audio-visual display, seeing and hearing the spatial nature of the speech, and speaking once again, that an uncomfortable and/or novice speaker could develop and use to practice conversation or self-expression.

Situating *Sea of Signs* in the Context of Media Technologies for Autism

Unlike many other state-of-the-art technologies targeting autism, the ecological validity of the work presented here is strengthened due to its installation at a school, through direct work with students and teachers. The design framework introduced in this chapter is grounded in the belief that an individual and his or her peers can engage each other with a minimal, multimodal layer of support. Currently media designers are prioritizing the development of sophisticated virtual tools like affective avatars (Konstantinidis, Hitoglou-Antoniadou, Luneski, Bamidis, & Nikolaidou, 2009; Luneski, Konstantinidis, Antoniadou, & Bamidis, 2008), virtual collaborative peers (Strickland, McAllister, Coles, & Osborne, 2007; Tartaro & Cassel, 2008; Moore et al. 2005), and virtual reality schooling (Lányi, Geiszt, Károlyi, Tilingerand, & Magyar, 2006; Josman, Ben-Chaim, Friedrich, & Weiss, 2008; Vera, Campos, Herrera, & Romero, 2007). While these tools can provide alternatives to traditional teaching, they also abandon the richness of real-world classrooms. Virtual systems may improve content delivery; however, individualized interactions and instruction that takes place solely through virtual worlds are limited by the set of cultural assumptions that designers have chosen to embed. Furthermore, they do not holistically integrate the living social contexts of their users because they require some degree of isolation, either by having participants wear virtual reality helmets, or by fixing their attention towards a single desktop screen. By contrast this research work augments the environment encouraging embodied interaction directly with human individuals rather than virtual agents.

Rosalind Picard, who heads both the Autism & Communication Technology Initiative at the Massachusetts Institute of Technology (MIT), and the Affective Computing Research Group at the MIT Media Lab, has studied the emotional states, stress, and arousal of persons with autism, and their ability to read others' expressions. Picard and collaborators have been investigating wearable technologies that sense affective states to enable greater emotional communication (Kaliouby, Picard, & Baron-Cohen, 2006; Picard 2009). Though this work has considerable value in the daily lives of youth with autism, it has not be deployed in public special education settings.

Finally, in a more broad statement about the nature of interaction design for educational environments, it seems that many current interaction design paradigms for youth with autism seek to fix symptoms of autism. This study does not seek to fix anything, but rather, it strives to value the person first by revealing his or her potentialities. Though a person may think, act, move, and communicate different, the objective is to elevate the person first, not the label.

Scenario Design: Process and Prior Work

Embodiment in experiential media design. Embodiment has been a key concept in defining and developing experiential media systems at AME. Sundaram & Rikakis (2008) define embodiment as “the idea that physical grounding is crucial to intelligence,” where “intelligence emerges through the dynamics of interaction with the world.” This definition builds upon Dourish’s (2001) description of an embodied system where meaning and action are tightly coupled, with meaning being the result of an emergent process achieved through action. Embodiment in experiential media is more than a unidirectional translation between physical movement and sound; it serves to extend ones reach into the physical-digital world. A person passively or intentionally manipulates an environment and takes notice, establishing a feedback loop that has the potential to engender a transformative experience reinforced through the media.

In his theory of embodied interaction, Dourish (2004, p. 205–6) highlights the physical and symbolic forms that tangible computing brings to digital information. Tangible computing best illustrates the link of action and meaning through physicality, which emerges in two ways. First, manipulating physical objects leads to the manipulation of digital information and functionality through data mapping. Second, the physical environment becomes a medium for expressing digital information using displays, lights, sound, movement, or other modes of feedback.

A hybrid, physical-digital media environment allows for the explicit design of multimodal experiences that fit with Andy Clark’s conceptual elaboration on cognitive action and extension. Namely, Clark proposes that sensory inputs get coupled (Clark, 2011, p. 15–17) with forward feedback mechanisms (such as visible graphics in the optic field) to create the potential for perceptual action loops (Clark, 1997, 36–39) that can co-activate neurons at convergence zones, i.e., zones that manage different kinds of knowledge and knowledge retrieval (Clark 1997, p.

138). It is possible that these convergence zones are functioning as activation points to generate the pivotal responses that R. Koegel & L. Koegel (2006) view as significant in enabling individuals with autism to transfer skills across situations.

General principles of design for the SMALLab environment. The EML at AME established core design principles for teams to create content for SMALLab. The SMALLab platform is an immersive media environment that fits within a standard classroom and is approximately 12' x 12' x 12' in size. The platform enables designers to integrate a motion capture technology, top-down projection, quadraphonic audio, input from customizable motion-tracked objects, and custom software for audio-visual feedback to create an interactive experience (see Appendix E for more information on SMALLab). Scenario designers for SMALLab implemented the following principles as part of a working strategy for building embodied and socio-collaborative experiences:

- Gesture to content mapping - Learners' physical actions have direct and causal impact in the simulated environment; and physical actions map to the content being learned (e.g., moving an object faster results in higher velocity)
- Alignment - A learner's gesture closely aligns with its function and role in the simulated environment (e.g, throwing gestures translate into thrown items in the simulation).
- Human scale - Computer interfaces support movements on a human scale (e.g., degrees of freedom, size and speed of a gesture)
- Communicative properties - Communicative and motivational aspects of human presence and gesture are taken into account (e.g., the cultural meaning of a gesture, the information conveyed by a gesture)
- Socio-collaborative properties - Social presence is accounted for in the design, allowing multiple, coordinated opportunities for team learning and reflection.

Prior work. Four years prior to this study, in Spring of 2008, I began collaborating with high school special education teachers and educational researchers to create four learning scenarios based on learning objectives for youth in special education. The strategy for designing and implementing SMALLab scenarios in the school was patterned after design-based research and design experiments (Barab & Squire, 2004; Brown, 1992; Collins, Joseph, & Bielaczyc, 2004), where direct collaboration within an educational setting culminates into a set of learning design principles. Langone, Clees, Rieber, and Matzko (2003) recognized design experiments as appropriate for studying computer-based interactive technologies with youth with moderate to severe disabilities. In this way, events or obstacles occurring during implementation could then be documented and handled continually as challenges arise (Langone et al., 2003, p. 11-12).

The iterative design cycles reflect a pragmatic approach to developing theory and practice for learning technologies, and the belief that context matters. This framework is currently in use by researchers in digital media and learning, in an attempt to develop a set of working examples[7] in the field. Collaborations involved two teachers, one or two education researchers, and me as lead designer. Specific learning objectives guided each scenario design within an overarching theme of facilitating social interaction and communication. Pilot studies were conducted using each scenario. Below is a brief description of each scenario, followed by the list of design heuristics for *Sea of Signs*.

Pilot study I, *Color Spheres*, an introduction to SMALLab. The *Color Spheres* scenario, first presented at the *Workshop on Media, Arts, Sciences and Technology* in Santa Barbara, California, (Tolentino, Birchfield, & Kelliher, 2009a) was designed as an introduction to the SMALLab environment for students in special education. To interact with the scenario, students used a set of silicone, motion-tracked glow ball objects. The scenario's main goals were to: (1) introduce students to the novel SMALLab environment; (2) apply learning principles that followed good game design (Gee 2007) and be conservative in coupling and implementing design features, with the insight that multi-sensory overload could occur for some students; and (3) determine if the scenario was legible and open or inviting enough to engage students.

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[7] Gee's discussion of a worked example refers to a concrete, clearly-explained example of "how some aspect (big or small) of their ideas, theories, claims, or hypotheses work in terms that people beyond their own disciplines or domains can understand, assess, and appreciate." This includes "how the author thinks about them, how the author sees them fitting into his or her area of expertise, and how the author thinks they might contribute to an emerging interdisciplinary field or collaboration." http://workingexamples.org/about, accessed September 27, 2012.

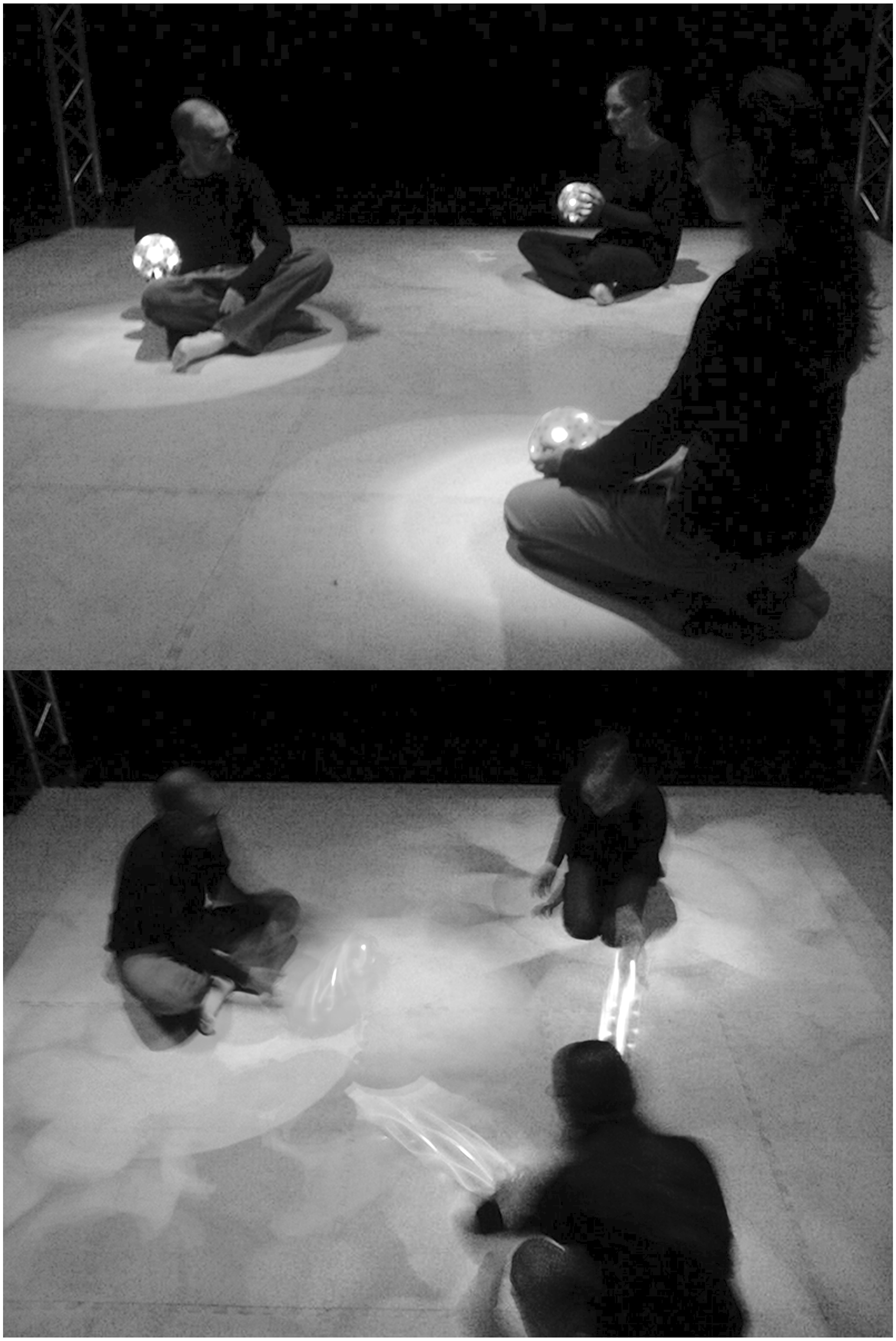

***Figure 4*. *Color Spheres* scenario for SMALLab. The top image shows three people with different colored glowball objects (orange, green, blue), sitting on three virtually projected colored spheres (orange, green, blue). When the ball rolls across its same color, as shown in the bottom image, colored particles flow out of the virtual sphere while music plays.**

The scenario and interaction design consisted of three large orange, green, and blue pulsing spheres displayed in triangular fashion on the floor. Each sphere was 3–4 feet wide, allowing students to stand inside. Three motion-tracked glow balls with colored LEDs (orange, green, and blue) were used to trigger the spheres, such that when a ball was held above its matching color sphere, the sphere emitted particles and generated tonal music.

Since this was the first time any students and teachers had encountered SMALLab, in a brief experiment, I wanted to see how they would respond to color, light, and sound, as well as how they would utilize the space. So the scenario was designed using pulsing, colored spheres that would burst into a stream of particles if a colored, motion-tracked ball was placed over them.

I observed roughly 8–10 students in the *Color Spheres* scenario. Some naturally explored the environment, walking around the space and rolling the balls on the ground in different directions. It was unclear whether they understood that each colored ball specifically triggered the colored sphere that it matched, even after they were told. During the scenario, the teacher introduced students one at a time. While in the space, one sang for a couple of minutes and then lied down in the blue circle. The teacher had no trouble getting her students to sit in a circle and roll the balls around to each other.

I found that the students and teacher seemed very comfortable there together. Aside from the singing and brief vocalizations of surprise at the particles, the classroom seemed to be quiet and waited for cues from the teacher for when to roll the ball to a partner. Upon returning to class, when asked by the teacher if they liked SMALLab, the students each indicated that they liked the activity.

Pilot study II, *Pong with Me*, for turn-taking & joint attention. The *Pong with Me* scenario was created to test whether participants could intentionally activate digitally projected images using a motion-tracked object. The scenario's main goals were to: (1) design a physically-based social experience that encouraged students to take turns, make eye contact, and exhibit joint-attention; (2) record and code physical or verbal behaviors; and (3) determine if the design was legible enough to enable freedom to take turns, but constrained enough to prevent unintended triggering of feedback. The scenario built upon the *Color Spheres*' design in its use of large circles, solid colors, and a simple dark floor. Colors for each student's circle were based on colors in the classroom that were used to code class-based tasks for each student. As each student took to the space, their name, color, and a picture of their face was displayed on a virtual ball that they would trigger.

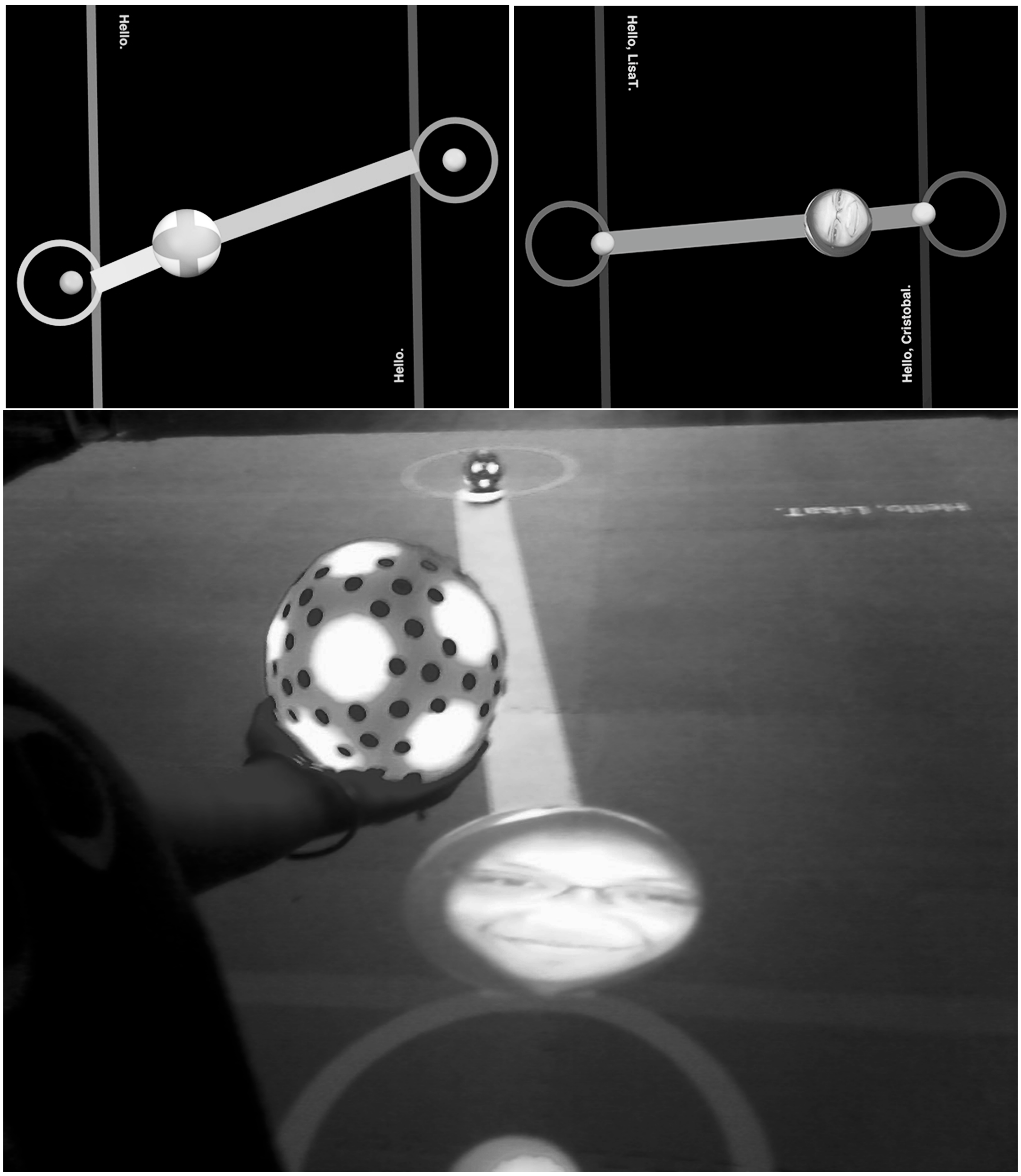

Figure 5. Pong with Me **scenario for SMALLab. The top to photographs show the generic (left) and customized (right) Pong settings. The bottom photograph shows a participant's view of the scenario, looking at her partner's face mapped to a virtual sphere, and preparing to use the glow ball to trigger the virtual ball to travel across the floor.**

In this scenario, students each stand in a colored ring, behind a matching boundary line. A large virtual ball (sphere) is displayed between them. Students' interaction goal is to take turns hitting the sphere to the other student. Once a student hits the sphere, the sphere travels toward the other side of the floor. At any given time, the ball shows its path trace, displaying the connection between students through the sphere. The design and results of the pilot (Tolentino, Savvides, Birchfield, and Johnson-Glenberg, 2010a) were presented at the GLS 6.0 Conference in Madison, Wisconsin.

In a short pilot experiment, I wanted to see if students would (a) take turns properly by staying behind the line and waiting for a turn to hit the sphere, (b) establish eye-contact across the space, and (c) show a behavioral indication that they acknowledged each other. One deliberate change was made during the activity, following a first round of generic play. This change was the introduction of a player's color, name, and picture on the sphere after it was hit.

During the first round of play, a generic looking virtual ball with generic colors were used. Some students had difficulty staying behind the threshold line on each side of the floor, indicating that they may have had trouble keeping it within their line of sight. Otherwise, students had no trouble triggering the virtual ball to pass back and forth across the space. Their eyes attended to the virtual ball as it moved.

Once their colors, names, and pictures of their faces appeared on the sphere, their attention instantly increased. For example, some students spoke out loud, stating and pointing to their name. Some students laughed at the face on the sphere, then said their name or their peer's name. Most students looked at the face of their peer on the sphere, and then up at their peer, i.e., demonstrating eye contact with peers standing a far distance from them. The teacher and teacher's face were also displayed in the space, and she was able to play with them. She encouraged them to explore the range of the space, moving far left and far right, enacting movements like she might during a tennis match.

During the experiment, spontaneous language and directed communication occurred when students saw pictures of their faces and their names appear on the floor display. Pong established that participants could take turns on their own. Students managed their interactions and took cues directly from the visual feedback without needing more than a few early teacher prompts. Their eyes also followed the direction of the sphere as it moved to their own or their partner's location. They had no problem triggering the sphere with their wands once they were given direction. The teachers and staff enjoyed the activity and expressed that even more, they liked being able to watch their students at a distance. The teachers observed behaviors and preferences that they were previously unaware their students were capable of doing. For example, one student called out her name, which was an important goal for this students' individual education plan. They also requested an additional feature of the interaction: to be able to include three or more people.

Pilot Study III, *Robot Collector*, for help-seeking skills. The main goals of the scenario were: (a) design a scenario that specifically focused on problem solving, troubleshooting, and seeking help; (b) introduce a physical element, the iRobot (Roomba) and gauge student interest and response; and (c) compare student performance in the SMALLab scenario with performance in a similarly styled classroom activity. Building upon the *Pong with Me* scenario, *Robot Collector* also used colored circles, pulsing spheres, pictures of students' faces on individually colored tokens, and a plain dark floor.

In this scenario, students guided the iRobot on the floor by walking it around using a virtual leash. As the student collected the colored face tokens with the robot, the teacher would secretly sabotage the robot to see whether students would proceed by seeking out another teacher or staff person for help.

***Figure 6*. *Robot Collector* scenario for SMALLab. This image shows a student bringing the teacher's attention to the broken robot, which spins in a circle and makes noise as a red light pulses around it. The student kneels and makes eye contact with her. The floor projection contains discs with photos of students' faces (blacked out here).**

Using a return-to-baseline design, a pilot study was conducted to compare a classroom-based collage activity with the SMALLab activity. In the collage activity, the teacher sabotaged the activity by hiding multiple essential objects to give students an opportunity to request and ask for help in acquiring each item. This was compared to the SMALLab robot activity, where the robot's mobility was sabotaged in order to give students an opportunity to ask for help to fix it. Students were introduced to the SMALLab activity in three steps: (1) guiding the robot around; (2) collecting face tokens; and (3) repairing the "broken" robot by requesting the tool to fix it. Students' responses to the broken robot were coded according to the rubric in Figure 7.

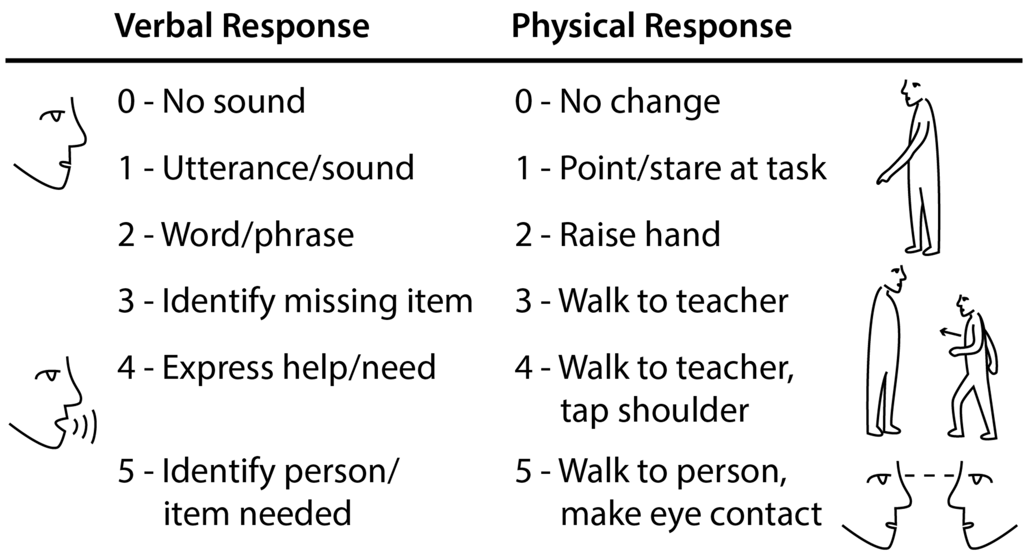

Figure 7**. *****Robot Collector*** **rubric for evaluating verbal and physical responses. The rubric was used to evaluate levels of response in both the baseline activity (collage) and *Robot Collector* scenario for SMALLab.**

Of the seven participating students who participated, four had autism. These students each demonstrated increased complexity in their verbal and physical performance (i.e., more vocabulary, more gesturing) when compared to a similarly sabotaged activity in the classroom. Following the rubric (Figure 7), all students demonstrated the highest level of verbal response at least once (see Figure 8). One of the non-autistic students identified as having mild mental retardation did not seem attentive to the activity and looked at the people around the space, ignoring or kicking the robot. In this scenario, we included the pictures of students' faces, along with a robot that would follow them—which they seemed to enjoy as well. The robot only had two modes of communicating: red (broken) and yellow (repaired) pulses. When it pulsed red, the students quickly and consistently learned to ask the teacher/staff for the wand to fix the robot. Teachers/staff then used this opportunity to shape their language, which remained fairly consistent and peaked throughout their remaining trials.

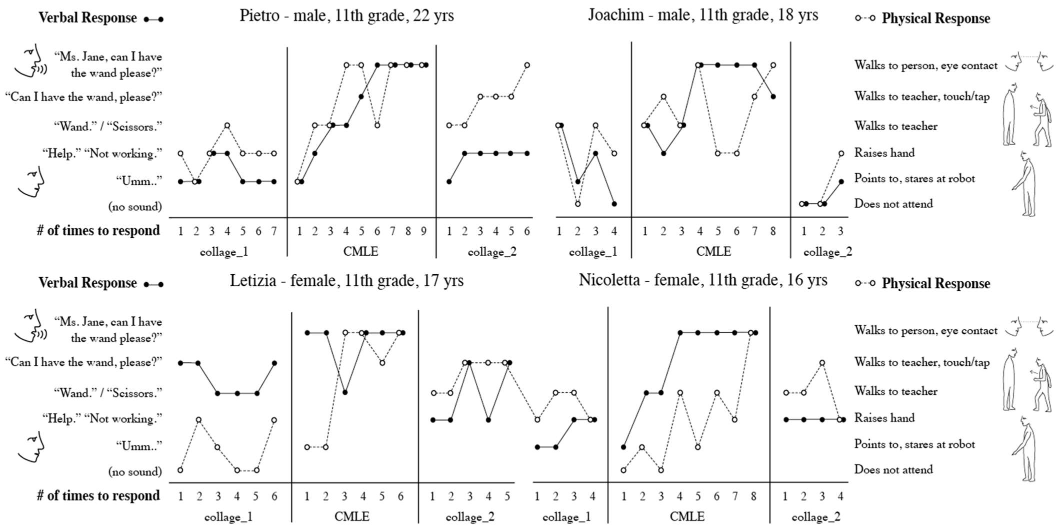

Figure 8. **Results from the *Robot Collector* pilot study. A collage activity in the classroom is used to establsih baseline. CMLE refers to the SMALLab scenario. Verbal and physical responses were rated using ordinal measures of complexity in vocals and movement, from simple words to full sentences, and simple pointing to eye contact.**

Preliminary results were presented at the 2011 Foundations of Digital Games Conference in Monterey, CA (Tolentino, Savvides, & Birchfield, 2010b). Figure 7 shows the results for all students who were identified with autism across three conditions—baseline (labeled as collage_1), SMALLab (labeled as CMLE), and a return to baseline (labeled as collage_2). For all students in the SMALLab trials, the use of complete words and vocabulary in verbal responses was considerably higher than the verbal responses they used during each baseline condition. The scenario suggested that students' language skills were enhanced or more quickly activated during the SMALLab scenario.

Pilot Study IV, *Crossing Guard Chicken*, for crossing the street. The main goals of the scenario were to: (1) see if rehearsing a simulated street-crossing procedure would result in transfer in the main space; (2) enable students to be "user testers" in the design process, where their reactions to design led to immediate changes within the audio-visual composition; and (3) gather teacher and staff reflections on the experience of their participation in the PLC, and their beliefs about the success, potentials, and/or difficulties of designing and using SMALLab.

This scenario served to improve the iterative design process and revealed information about effective color contrast, size, and placement of elements like virtual sidewalks, crosswalks, and speeding cars. For three days, students used the scenario as refinements were made. The scenario extended the robot helping narrative: the robot was now trapped on one side of the street, and students had to figure out how to bring it back by following the rules of the road. Cars continuously drove on the street until a student waited at the stop. After waiting for a while, the cars paused, and the student could cross. When the student reached the other side, the student would tap the robot with their wand to activate it, and the student would once again wait until it was appropriate to cross back. Each student took turns cycling through the scenario.

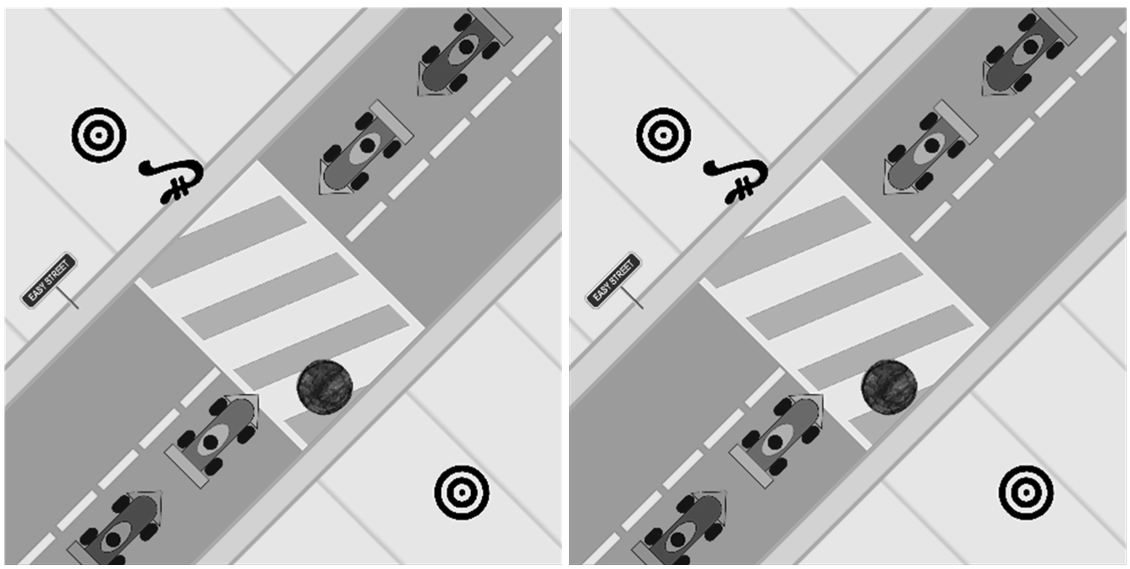

***Figure 9. Crossing Guard Chicken* scenario for SMALLab. This is the top-down view of the final iteration of the scenario, pilot-tested by students. By this iteration, the sidewalks were bigger, target circles were created as destinations for the robot (denoted as black circle in this scenario), and moving cars were introduced to give context as to why students needed to stop and look both ways before crossing.**

An ABA reversal design was attempted to see if students improved their ability to cross the street. This experiment lasted longer than expected because students did not typically practice crossing the street (since it is outside of the classroom). An evaluation team was hired to develop tools to evaluate students' baselines for following appropriate protocol before crossing the street. Prior to the baseline, students and teachers met with the crossing guard to receive a lesson in crossing the street. Students also took a couple of field trips to the park across the street, so they could practice beforehand. A baseline was established by assessing students' street crossing skills in a bus parking lot area, with supervision by teachers.

In SMALLab, students actually served dual roles. The first was unexpected, but they became our pilot-testers when we realized that our design was insufficient for their use. This became clear when we noticed that students were: a) distracted by the quiet background traffic noise, and b) students with visual impairments had a difficult time discerning where to stand or how to follow the narrow, straight line that represented the sidewalk. Students came in three days in a row, and each day, we made a new modification. Students were then tested on the real street outside. The assessment design was presented at the 2010 Global Learn Asia Pacific Conference in Penang, Malaysia (Quick et al., 2010).

Students were less successful performing in this scenario than students in the three previous scenarios. It is possible that the protocols for interaction were too complex, or that the scenario itself did not facilitate or motivate participation. No pictures of faces were used in this scenario. The sound of the traffic was also decoupled from the activity on the street. The scenario did confirm that students could get used to looking for cues (such as moving cars) in the environment. However, it was also clear that some students were distracted by the richer imagery. Furthermore, the robot was not virtually tethered to the wand, which may have made it more difficult for students to know whether they had control over guiding the robot or not.

Overall, the scenarios suggested that it was possible for students in special education, and particularly those with autism, to be motivated to learn in this kind of environment. With the right feedback and interaction design, students could participate independently enough to the point that teachers could pause, observe, and reflect on students' capacities in different ways. Another benefit was that each scenario elicited spontaneous communication. The limitations for these designs, however, included that students had no room to creatively interact (everything was task-based), and that they were designed for either one or two participants, leaving other students to sit on the sidelines.

Design Heuristics for the *Sea of Signs*

Conceptual design for the Sea of Signs. The *Sea of Signs* scenario was designed to encourage self-expression by extending and augmenting vocal acts into SMALLab through aural and visuo-spatial feedback. The goal of coupling the voice with multimodal feedback was to encourage a participant to speak by extending his or her speech into the environment through a wash of color and resonance. The amplified feedback surrounded a speaking participant to encourage a feeling of presence that resulted from vocal acts. The scenario was designed to promote self-expression using a wireless microphone, turn taking through the exchange of an object, and directed communication using visual design, all at a slightly slowed time scale. The pattern and time scale of exchange was intended to give youth a chance to visualize the conversational activity at a meta-level.

Design choice 1: Making visible that which cannot be seen. Sound exists on an invisible, spatial front. To attempt to deliver a lesson about understanding sound or voice to students with autism, using only a sonic medium – vocal instruction, seems contrary to making the content accessible, because of the very reason that students' ability to process sound is compromised due to their autism. Dourish (2004) states the obvious of invisible interface design: "You cannot be engaged with something that essentially isn't there. Invisibility is not engaging; invisibility does not communicate" (Dourish 2004, p. 202). Our mouth, our vocal folds, and our resonating bodies are tools we use to produce voice; however, we cannot actually see our instrument. We can only feel it resonating when we use it. If we consider that persons with autism have a physiologically difficult time parsing their own sensory experience, it makes sense to offer them a way to lean on their visual capacity as a way to strengthen how they make meaning of their voice in the world. The voice needs to matter in the visual domain, just as the face of the person we engage needs to be present in close proximity or periphery to us.

Design choice 2: Developing and reinforcing conversational interaction patterns. Conversations between two people have a small handful of salient features. For example, taking turns is a requirement. In an immersive media environment, turn-taking can be physically and visually encoded through the exchange of an object, which may be a story stone, a talking stick, or some shared item. To enhance the symbolic expression of the intent to share one's voice with another, using the object to capture the voice can reinforce that intention. For example, a microphone, audio sensor, or device that can symbolically receive the voice may be embedded in the object.

Because the experience happens over time with some variation in content (verbal, physical gestures, people), a pattern would form around what remains consistent between sessions and what changes. What remains consistent is the frame around the conversation. Two people must each choose the content and length of expression, initiate and take turns in expressing content, and activate their voices in that process in order for a change in the media to take place.

Design choice 3: Conversation as a dynamic and fluid system. Steven Gutstein, founder of the Relational Development Intervention Program[8], grounds his work in with individuals with autism in a theory of *static* versus *dynamic* intelligence, where individuals with ASD prefer more fixed or static systems to more fluid or dynamic systems (Gutstein, 2009). For example, photographs and fixed rules for dialog would be examples of static systems, whereas facial features and vocal inflections would be examples of dynamic systems. Having the autism label suggests that a person has restricted and/or fixed patterns of behavior and interests, and in this way, a preference for more static or predictable systems. If the goal of teaching social interaction skills is to grow students' interest in conversations with other people, then it makes sense to design a learning experience that enables transition from static to dynamic systems. Media tools have this potential to enable the integration of fixed artifacts, like pictures or social cues, with more dynamic artifacts, like animations generated in real-time.

Design choice 4: Continuity and connectedness using Gestalt principles. Building upon Gestalt psychology (Köhler, 1947) and its fundamental law of prägnanz, the brain is believed to have self-organizing tendencies. Specifically, our senses recognize and organize around the perception of whole figures versus collections of simple, discrete parts. Three Gestalt laws inform the design:

1. proximity, where the spatial or temporal location of items cause us to perceive a collection or totality of elements;

[8] More on the theory of the Relational Development Intervention program can be found at http://www.rdiconnect.com/pages/Publications-by-Steven-E-Gutstein.aspx

2. continuity, where continuously generated visual, auditory, and kinetic patterns support the feeling of flow or dynamism over time; and,
3. common fate, where particles moving in the same direction are seen as a collective unit.

Gestalt principles suggest that certain design choices can trigger the brain to perceive certain qualities of experience. The law of continuity means that our visual system will cause our eyes to follow a line when it perceives a line, drawing our eyes from one point to another. Another example would be that a group of particles spaced closely together appear to belong to a single entity, such as a cluster. A visual projection of an organized flow of particles between two people may suggest a fluid transition or connection between the two in a way that parallels the nature of vocal expression and its meaning, as it shifts, moves, accumulates, and fades over time.

As the voice affects the fluid rate of particles, the particles are suggesting an aesthetic about the voice—namely, that self-expression is dynamic like a cloud, not static like written text. Because the projected particles are continuously generated from a locus at the center of a participant's physical body, then there is a mediated sense that the particles are streaming out of the participant, in all directions, and also directly to a participant's partner. The particles are, in effect, an extension of the voice as it travels through the body, resonating from within before being broadcast throughout the environment such that as the participant speaks, he or she can still see the effects at the periphery of his visual field.

To highlight the relationship between the participants, there are a couple of elements. A line drawn between two participants highlights the implicit relationship between them, providing a visual metaphor that expresses the concept that *you are always connected*. The line, which has a picture of one of the participant's faces on it, provides a reminder to each of the participants that it is or will soon be time to initiate conversation with your partner. Finally, in assuming that the experience is memorable, the associations or learning that occurred in the environment may be able to be triggered by the participants themselves. Each participant is active as a player and co-constructor of the environment. If learning in SMALLab is a success, then participants should start to seek each other out more during class.

Design choice 5: Minimal design to help focus attention. One goal of learning design for youth with autism is to manage over-stimulus while helping students find clarity around a complex subject. It follows that an activity should highlight only the most critical or salient features that belong to conversational interaction. Turn-taking, exchanging something at your own pace, speech flow, continuous focus on a partner, a sense of place, and a sense of connectedness between two people belong to this set of features.

Design choice 6: Aesthetic is consistent with speech being open and free. For the design of an experience to present an aesthetic that vocal self-expression should be free, open, and voluntary, the pedagogical approach to the space should be consistent. This means, participants' prompts or encounters with the teacher should be positively reinforcing. In addition, the teacher should feel openness in the interaction and comfortable responding and adapting to the feedback, students, and environment. Elements for exploring openness include:

- Space, where there are minimal or no hard boundary lines or requirement to be "inside" or "outside" of the experience.
- Time, where there are no time limits on length of turns.
- Sound (resonance or reverberation), which subtly reinforces what is already there, lifting the voice out of texture.

CHAPTER 4

Experiment and Scenario Design

This chapter describes the experimental procedures for data collection. This mixed-method study drew upon methods from experimental psychology and was further reinforced by ethnographic data gathered during the experimental phase. Both participant observation data and teacher interviews were used to interpret each student's communication, cognitive, and social interaction profiles at baseline and throughout the experiment. The experiment focused on catalyzing vocal expression in an embodied media environment. Self-expression is defined as spoken material independently generated by a participant. Here, I assess it based on

- improvements in speech patterns during two different SMALLab settings, when compared to a baseline condition;
- the degree of variance and maintenance of these patterns throughout the course of the experiment; and
- change in the number and/or quality of teacher prompts needed to motivate a participant to express him or herself vocally.

The participating teacher's perceptions and awareness of students and teachers were also tracked across sessions.

Objectives

The goal of the study was to analyze the extent to which an immersive media learning experience encouraged greater self-expression for youth with autism. Here, the term *self-expression* refers to spoken material that a participant generates independently, without direct prompting from an external aid (e.g., teacher or hand-held cards). Improvements in self-expression included moving from prompted phrases to self-initiated phrases, increased speech interactions with partners, and an increase in unique phrases across sessions.

The learning experience was composed for the SMALLab environment. SMALLab is a physical-digital environment consisting of flexible inputs and outputs (video, audio, motion-capture, and robotics) that allows designers and programmers to custom-build a multimodal experience, also known as a *scenario*. SMALLab scenarios are designed to make use of its specific affordances, which then coalesce to form a situated context (Lave and Wenger, 1991) around some activity. The scenario in this study transformed auditory and spatial inputs into a dynamic, audio-visual field to enhance and make visible the implicit features of an intimate conversation. Thus, aural, visual, and spatial dimensions of SMALLab were simultaneously activated to augment reality of space, as discussed below.

An aesthetic of conversation. The scenario for this study was conceptualized as a setting that supported intimate conversation with a friend. Hunicke, LeBlanc, and Zubek's (2005) Mechanics-Dynamics-Aesthetics (MDA) game design framework was applied as a template to design the aesthetic learning experience. In a game or a given experience, a core aesthetic (or core set of feelings) is brought about through mechanics (or rules) that have been designed to amplify relevant feelings. As participants use the rules or dynamics, participants' behaviors start to emerge.

This study implemented a scenario called *Sea of Signs* that captured the core aesthetic of intimacy in conversation with another person. Two primary mechanics were used and are described below. The dynamics were then tracked and analyzed to determine whether the scenario successfully encouraged self-expression and connections with their partners. The resultant SMALLab scenario is the *Sea of Signs*, with two variations: SMALLab Setting 1 and SMALLab Setting 2. Setting 1 focuses on getting participants to recognize that their voice impacts the environment. Setting 2 encourages participants to seek each other as they speak.

Core mechanics of conversation. To design the core mechanics for this scenario, the features of conversation were distilled into what I observed to be a minimum structure for focusing on conversational practice—i.e., speaking, turn-taking, and awareness of a relationship between one's self and another. The scenario can be thought of in terms of two types of features: concrete and abstract. Concrete features are physical and integrated with abstract features, which augment physical ones through digital means.

Concrete features:

1. Two participants are physically present.

2. A motion-captured, tracked object (herein referred to as “the shell”) with a wireless microphone inside.
3. Vocal signals produced by participants.
4. The shell’s movement from one person to other.
5. Two rugs, circular and motion-tracked, provide a place for participants to sit.
6. Personnel:
    - A teacher who intervenes and prompts students as necessary.
    - A media designer who monitors the quality control of the environment.

Abstract features:

1. Visual floor display generated by vocal acts.
2. Visual floor display altered passing the shell.
3. Sonic reinforcement (amplification and reverberation) of vocal acts, coming through ceiling-mounted loudspeakers that surround the space.

These features are integrated to produce physical-digital mechanics that structure conversation in this setting. Two core mechanics exist for this scenario: (1) speaking into the shell, and (2) taking turns by passing the shell. Both are described below.

Mechanic #1 – Speak into the shell to generate feedback and content. The first mechanic is speaking into an object with a wireless microphone inside. Here, the object is shaped like a large nautilus shell that can be held in one or two hands. Reasons for putting the wireless microphone into an object were both practical and aesthetic. First, it provided a portable, pleasing interface that was comfortable to hold. Second, a shell shape has a natural, protected open hole that helps direct a user to it. Third, the object has only one input, helping to further focus its use to three modes—holding it, making sound into it, and passing it on—while keeping the wireless unit protected. Fourth, the strong visual element serves to help both participants directly perceive the fact that a person is speaking. When someone speaks into the shell, dynamic, colored particles stream out around the person. In addition, the wider the pitch variance in a speaker’s voice, the more multi-colored the particles are. This feature was created to give speakers a greater sense of agency in that the environment’s response was more nuanced to their vocals.

The shell as an aesthetic element is part of a larger metaphor described in the scenario title, *Sea of Signs*. The *Sea of Signs* is inspired by a catalog of prose scores written by American composer and phenomenologist, Alvin Lucier. Lucier's collection of scores and interviews, which are published in his book *Reflections* (1995), offers homage to the unique qualities of sound and sound sources that can be revealed through its surrounding environment. Many of his pieces are specifically composed to focus on activating the environment or an object such that otherwise hidden properties or qualities of that object emerge. One such piece, the "Queen of the South" (1972), generates visual imagery by applying sound to vibrating media. Personal identities are not immune to the process. In "Duke of York," Lucier builds an experience whereby a vocalist and synthesist-performer work together in a live, serial process, to reproduce a serial set of personally historic and intimately significant texts as they attempt to recreate and/or re-imagine the history and identity of the vocalist for themselves and their audience.

Though the experiment was not designed for performance in the classical sense (as traditional art, music, or theatre), it is staged such that it draws influence from the phenomenological and revelatory aspects of Lucier's work. SMALLab is an instrument in that it is a sympathetically vibrating environment: a dark, open, and fantastical kind of expanse, like a metaphorical sea. Participants play within this instrument/environment, which is meant to be an echo chamber or extension of them. The shell, which came from this "sea," becomes a mediating conduit between physical and digital worlds, as well as a shared symbol between participants. It is an intermediate channel that ports the voices of physically present, co-located human beings into a virtual dimension—one that transforms the voice into a dynamic audio-visual field, one with aural, spatial, and visual resonance that reveals itself as colored waves. These waves ebb and flow in response to the presence and absence of a person's voice.

Mechanic #2 – Take and offer turns to speak by passing the shell to your partner. Two setting variations of Sea of Signs were administered in the study. This mechanic relates to the second setting. Between both participants is a shared colored line that connects each partner's ring. On the line sits a picture of one of the participant's faces. When a person is taking a turn (i.e., has the shell), the picture shows his/her partner's face, which rests at the edge of the speaker's circle. The picture serves to remind the speaker whom he should talk to. When the speaking person finishes his/her turn and moves to hand the shell to his/her partner, the pictured face changes to that of the speaking person, as a symbol of who just spoke. The picture slides towards the partner who now prepares to speak. The aesthetic choice to have a person's picture travel between people serves as a symbolic gesture acknowledging and marking that the speaker finished his or her turn and was transmitting a message to the partner. The picture also serves to remind the speaker of where the message came from, and whom to talk to.

Dynamics: participants in the rules of conversation. This section describes the flow of the interaction. It begins with an idealized narrative of what the users experience in the space, followed by a more technical description of the physical components and software processes involved.

The lines that run between each person's circle and the picture are there to help draw the eye from one person the other. This visual technique follows from Gestalt laws of perception and organization (Köhler, 1947; Wertheimer, 1923)—most specifically, the law of connectivity, where lines are seen as following the smoothest path (Köhler, 1947)—and the law of grouping, whereby two objects that are seen near each other are often grouped together by the mind (Wertheimer, 1923). These laws were incorporated into the scenario design to direct students' focus toward:

1. Connecting with another person. The visual layout included dynamically generated particles that traced a line linking each participant with the moving face.
2. Taking turns as speaker or listener. The shell acts as a shared object to indicate whose turn it is to speak. When it is held within a participant's circle and spoken into, particles emanate from that location. When it is handed to the partner, the picture slowly glides in the direction of the person receiving the shell.
3. Temporal nature of speaking. To produce particles, a participant has to speak actively—that is, above a minimum length with enough volume to be heard by the microphone. Particles get generated when the length and loudness of the sound entering the shell reaches above set thresholds.

4. Opportunity to be flexible in expression and content. The scenario enforces neither maximum speaking length nor content choice; both are left open to the speaking person to choose. Furthermore, if the speaker varies his or her vocal inflection, the particle colors become more colorful and less monochromatic.

The design consciously subtracts the teacher's presence in the space. The goal of de-amplifying the role of a mediating authority is to give students' a greater sense of agency and presence in the activity. Furthermore, by off-loading interaction management structures (e.g., specific places to sit on the floor, a single object to share, no unnecessary peripheral graphics) onto the environment, the teacher has greater freedom to assess students' performance and scaffold learning (Vygotsky, 1978), intervening only when absolutely necessary. It should be noted that this approach is contrary to industry practice and is deemed viable only by the addition and careful design of the immersive and interactive environment.

Overall, the mediated features are there to encode a lean and dynamic structure that students can use to manage turns on their own. Students then have freedom to fill in this structure with their choice of speech acts and verbal expression. By acting on and within this multimodal environment, they create meaning by simulating embodied patterns of conversation and social interaction that have been extended by media. Furthermore, by having their own bodies and voices extended and integrated into the environment, they themselves become somatic representations or human artifacts (Norman, 1993, pp. 49–52) that help trigger memories of the experience once they leave SMALLab.

Methodology

Hypothesis. Given an embodied and mediated scenario, this study examines whether a person's behavioral patterns of self-expression and social referencing change and stabilize over time. The underlying assumption of the study is that a participant will demonstrate greater self-expression in a setting in which he/she feels sufficiently embodied—that is, he/she feels a strong sense of presence, agency, and immersion. From this perspective, a claim or evaluation of embodiment lies with the person experiencing his or her world. Thus, a scenario designer looking to encourage an embodied experience should follow the embodied media design framework set forth in Chapter 3. Given this assumption and subsequent design framework, I hypothesize:

If the scenario, *Sea of Signs*, was adequately designed for the target audience—that is, persons with autism—then the data should show marked and lasting improvements in participants' self-expression and engagement with peers across sessions.

If instead, lasting behavioral improvements did not emerge for a participant, then the scenario design was not sufficiently embodied for him or her. If no lasting behavioral improvements were recorded for any of the participants with autism, then the conclusion would be that categorical experiential assumptions made about persons with autism could in fact be misaligned with participants' actual learning preferences.

Research Design

This multi-method study draws on multiple baseline methods from experimental psychology and is further reinforced by ethnographic data gathered throughout the experimental phase. All sessions at baseline and in the SMALLab scenarios were videotaped to allow for participant observation data to be coded along with written observations. Observable, physical, and verbal behaviors remain the focus of the study, where focus is defined through Ihde's framework. Though the study focuses on pre-determined assessment criteria (e.g., mean length of utterance, turn-taking, and prompts given), *fringe* or unanticipated behaviors are also documented and tracked as possible markers of participants' intentions to communicate.

Data Collection.

Research Site. The study was conducted at a Title I public high school in a large city in the United States. The SMALLab infrastructure was previously installed in a classroom at a high school campus in 2007. SMALLab's presence at the school was established through a federal grant for a collaborative partnership between the school and AME. Following a series of demonstrations given by the SMALLab founder, Professor David Birchfield, the school administration put out a call for teachers to participate with the SMALLab design team. My interest in working with participants with disabilities led me to the school's special education community. In the Fall of 2008, I partnered with a graduate student in education technology to meet weekly with special education teachers in the PLC format (Hord, 1997). For three years, this special education PLC identified significant learning objectives for students and subsequently designed and implemented a series of SMALLab pilot scenarios to help students meet these objectives. Results and observations gathered from these pilot studies have led to a set of heuristics contributing to the design of this study.

Recruiting participants. Participants were recruited from one specific classroom of special education students that mostly contained students whose official diagnoses were autism. Recruitment was done in accordance with procedures approved by the University's Internal Review Board (see Appendix A–D). All students in the class were invited to participate, and a total of eight students both assented and submitted their parents' consent forms. This allowed for four unique dyads (pairs) to form. Teachers grouped the kids based on their current pairings from ongoing speech therapy, which were originally created according to their compatibility and amicability toward one another.

Teacher interviews to develop students' profiles. To record a thick description (Geertz, 1973/2000) of each student's communication and cognitive preferences, I interviewed two teachers about students' behaviors in the classroom. Examples they shared during the interviews were used to help decode and construct the nature of participant behaviors during the baseline setting. Throughout baseline, I also made note of any behavioral patterns that emerged. I then administered shorter follow-up interviews each day to review these behaviors and their possible sources with the teacher assisting in SMALLab.

Teacher interviews were conducted in three phases: pre-experiment interviews, daily debriefings following the baseline and SMALLab conditions, and post-experiment interviews.

1. Pre-experiment interviews (60–90 minutes), to collect descriptive examples of each child's cognitive processes, preferences for learning, leisure choices, problem solving styles, and daily cycles and schedules.
2. SMALLab debrief sessions (15–20 minutes per dyad session each day), to triangulate and interpret students' behaviors in SMALLab.

3. Post-experiment interviews (60–90 minutes), to gather teacher reflections on the experiment, to gauge their view on possible developments in student behavior after the experimental phase, and to document their perspectives on teaching in the SMALLab environment.

I developed a general interview guide (Seidman, 2005) (see Appendix F) to encourage teachers to share concrete examples of how each child communicated needs, the circumstances under which they engage others, and their level of mastery in verbal communication. The interview guide was adapted from the SCERTS Model for individual student assessment in the “Language Partner Stage” and “Conversational Partner Stage” SAP-Report Forms assessment questionnaire (Prizant, Wetherby, Rubin, Laurent, & Rydell, 2006). The SCERTS Model Framework—which stands for domains of Social Communication, Emotional Regulation, and Transactional Support—is an evidenced-based practice for implementing interventions in real-world settings (Prizant, Wetherby, Rubin, & Laurent, 2010, p. 3). One of SCERTS’ priorities is to address the core challenges of ASD by “building on a child’s capacity to initiate communication with a pre-symbolic and/or symbolic communication system, and to regulate attention, arousal and emotion” (Prizant et al., 2010, p. 4). The SMALLab scenario in this study was designed with parallel motivations, making the SCERTS-based questionnaires relevant for conducting preliminary student assessment.

Prior to scheduling interviews, teachers were given consent forms indicating that their participation was voluntary, that interviews were videotaped, and that teachers could ask to stop recording at any time. Teachers were also offered the option to review transcriptions upon request in order to reconfirm their notes.

Observing baseline and SMALLab trials. The experiment uses a template that follows a multiple-baseline design across settings, which is standard for on-site special educational research (Kennedy, 2005, pp. 150-162). Settings in this experiment take place in a classroom containing SMALLab that is separate from the students’ homeroom. In the SMALLab classroom, the environment is altered by adjusting the lighting and sound and through the addition of a floor display and motion-tracked objects serving as inputs to the SMALLab environment. Eight students were divided into four dyads that would remain the same for the duration of the study.

Each dyad began the study in a baseline setting, followed by two SMALLab scenario settings. Each pair had multiple sessions in each setting and was introduced to these settings in a staggered, stepwise fashion. The first pair received the first SMALLab scenario setting. This pair was monitored for multiple sessions until a change in behavioral patterns was perceived. Once change was perceived, the second pair then received the first scenario setting in their session. After change was observed in the second pair, the third pair received the first scenario setting. This procedure continued through to the fourth pair. Once all students received the first setting, the second SMALLab setting was introduced to the pairs in a similar, stepwise order.

Audio/video recording sessions in SMALLab. Throughout baseline and scenario sessions, students were video recorded from one or two angles. For baseline, students were seated on the floor facing each other while the teacher sat between or behind them based on students' levels of motor control. One High Definition (HD) camera was placed at the side of the SMALLab floor, approximately 6 feet away from students at eye level with them. During SMALLab, one additional camera hanging in the classroom's upper corner was used to record a top-down/side view of student activity. The shell's audio was also used to further supplement video with a higher-fidelity speech recording.

Behavioral assessment criteria. The study was designed to analyze students' patterns of vocal activity and whether they changed over time in the areas of

- mean length utterance, per session;
- total number of utterances and length per session;
- number of turns and length per session;
- central tendency of ratio between speaking and silence, per turn, across session;
- behavior patterns with turns: requested, received, and rejected; and
- behavior patterns and frequency outside the scope of expected exchange pattern (i.e., using shell as a percussion instrument, walking away, getting or responding to partner's other attempt to get attention).

Measures. For video coding, behavioral data were labeled and organized to chart direct observations by the teachers and experimenter, as well as video footage and audio recordings. This data was analyzed for repeated or consistent verbal expressions, i.e., patterns with careful attention to events or circumstances that were coupled with the expression (e.g., teacher prompts, student speaking when out of turn, announcement over loud speaker, student leaves the space, etc.). Quantifiable events (countable items, elapsed time) were recorded and plotted on a graph. Calculations based on the ratio of "speaking versus turns taken" during each session, and across sessions, were examined to determine if verbal self-expression and social interaction improved over time.

Procedure. The procedure for each pair of students going to and from each SMALLab session is as follows:

1. To get into each SMALLab session, prior to leaving the homeroom, the teacher asked the pair of students whether or not they wanted to go. If they chose to go, the teacher would let them lead as she followed, taking about 6 minutes to walk across campus from their homeroom to SMALLab.
2. Upon arrival, students knocked on the door, which I then opened. As they came in, the teacher asked them to remove their shoes before stepping on SMALLab's soft floor. Once shoes were removed, they walked onto the mat and immediately sat down during the baseline phase. Alternatively, during the SMALLab scenario phase, they dragged their rugs onto the mat and sat on the rugs. The teacher helped them adjust their bodies and/or the rug as necessary so they faced each other.
3. Each session in SMALLab lasted approximately 15 minutes. During a session, students were encouraged to say or express anything they wanted (they could generate their own content). The teacher waited about a minute to see if they had something to say. If not, she offered them a suggestion or topic prompt, either verbally or using topic cards she had made. However, if students were already speaking and generating their own content, she did not intervene. If students seemed distracted and acted on it (e.g., standing up, leaving his or her rug; trying to open up the shell), were consistently inattentive to their

partner (e.g., looked everywhere except at their partner), or had problems holding or passing the shell, the teacher tried to redirect their attention by physically pointing and/or modeling a more appropriate action.

4. Once it was time to leave SMALLab, the teacher was quietly cued to tell students it was time to return to class. Students stood up, dragged rugs off of the floor, gave me the shell, put their shoes on, bid me farewell, and walked back with the teacher.

Technical support during SMALLab sessions. Throughout the scenario, I sat behind a desk of computers, monitoring the SMALLab technologies and removing myself from potential eye contact with students. I started the video archive systems, timed the session, and made sure that motion capture was working properly. During the scenario phase, the room was dark, and I covered up any potential distractions (e.g., computer monitor screens that reflected on the white board behind me).

For each dyad, I loaded color presets and pictures of students' faces associated with the current student pair. The colors and pictures were obtained during their leisure time in class. Students sat down with me and I took a high quality snapshot of them looking directly into the camera. Their faces, from shoulders up, were then cropped and set against a colored background with their name in white. The color background was based off of a color scheme the students were already using to identify their scheduled tasks in class. For example, one child's activity schedule was outlined in red, while another's activities were set in blue. The reason for applying these colors was to customize the SMALLab experience to help make each student more comfortable.

During baseline and the first scenario settings, I monitored and adjusted audio levels to be at comfortable levels for the students. I also fine-tuned audio thresholds in Unity3D and PureData to ensure that visual feedback was appropriately triggered. During the second scenario setting, I also changed and triggered the picture between turns, such that picture movement corresponded directly with one student passing the shell to the other.

Settings

Following from the embodiment theory presented in Chapter 3, the SMALLab scenario was designed to help each participant move from being expressive, active, and self-aware, toward an awareness of the relationship they have with each other. The scenario design built upon the set of design choices derived from the four SMALLab pilot studies presented in Chapter 3. The design choices were implemented into the three experimental conditions (baseline, SMALLab 1, and SMALLab 2) using the shell interface and the SMALLab infrastructure to dynamically generate particle graphics through Unity3D. These design stages are presented in Figures 10 through 12. The voice (in the center of Figures 10-12 figures) has sonic properties that can be analyzed (e.g., for loudness, pitch, and duration, as shown in Figure 12) and transformed into audio-visual feedback. In addition, Figure 13 provides a close-up view of the shell and a participant-eye-level view of the interaction.

The design choices presented in these figures correspond with the baseline, SMALLab 1, and SMALLab conditions 2 in the actual study.

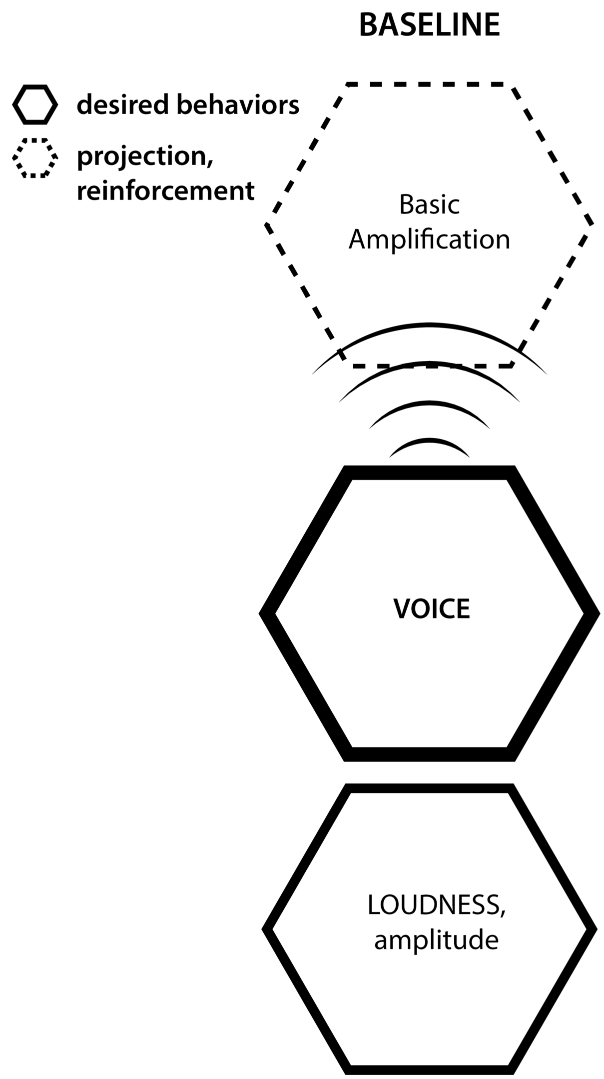

***Figure 10*. Design stage 1: Reinforcing the voice through basic amplification. This figure shows the design concept for the baseline condition. Vocals received through a wireless microphone in the shell object receive basic amplification through the surrounding speakers. This is to see if students are drawn to speak by simply noticing their voice elevated in the room.**

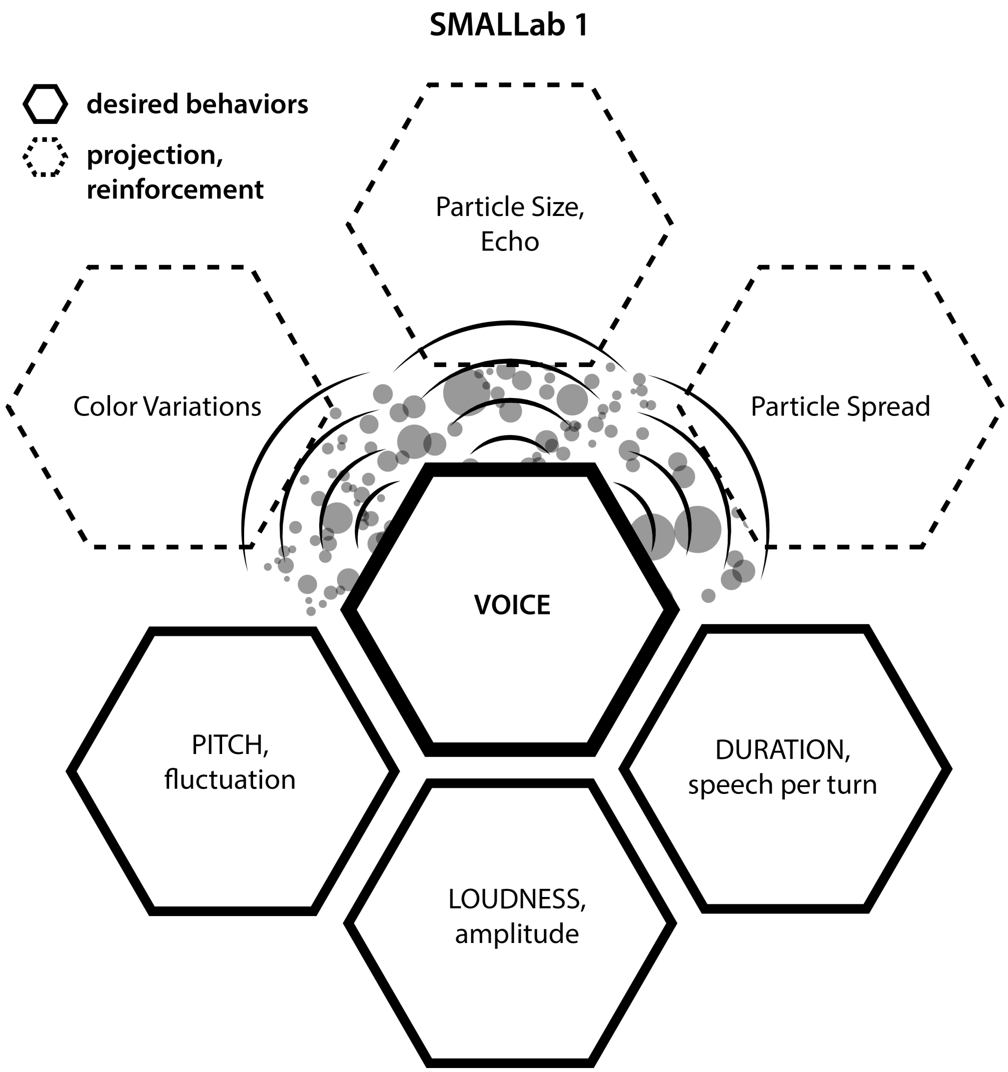

***Figure 11*. Design stage 2: Amplifying the voice through immersive media feedback. This figure shows the design concept for the SMALLab 1 condition. Three features were derived from the voice coming through the shell object, to control different aspects of the visual design. Pitch fluctuation was scaled to cause particle colors to change (monotone causes no color change; varied pitch creates multiple colors). Loudness was used to vary the size of particles (louder voice produces larger particles, softer voice produces smaller). Duration was used to encourage longer speaking times for each turn (more speech per turn yielded a greater spread of particles).**

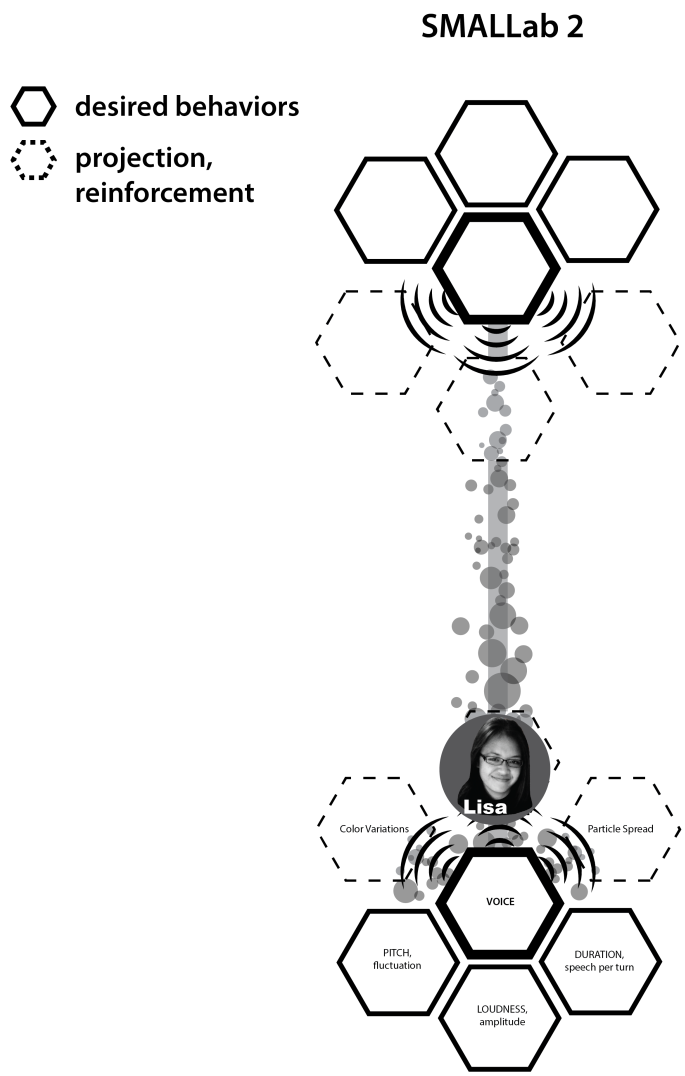

***Figure 12*. Design stage 3: Connecting partners through immersive media feedback. This figure shows the design concept for the SMALLab 2 condition. As a person speaks into the shell object, the same particle system behaviors are preserved from SMALLab 1, with the addition of a stream of particles that travels directly towards his or her partner. There is also a line that gets drawn between both people. When the speaking person is finished and passes the shell to his or her partner, the person's image appears and travels along the line towards the new partner, to symbolize an exchange of turns.**

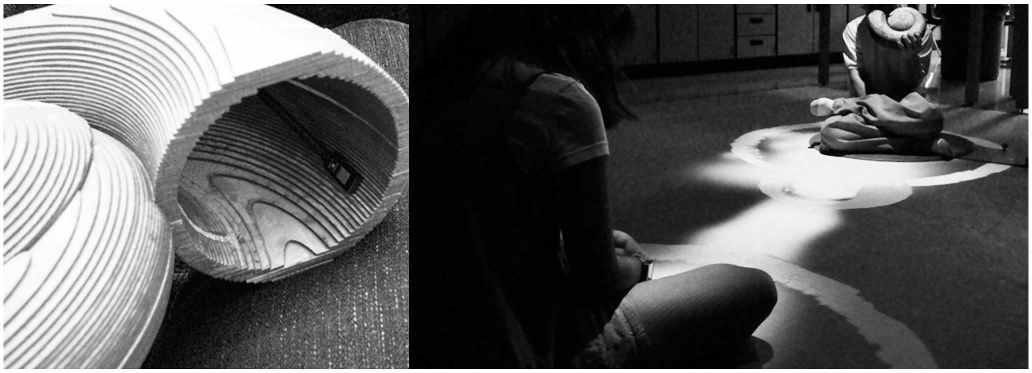

***Figure 13. Sea of Signs*, close-up view. The wireless shell interface (left) is shown with the microphone element, which is concealed with foam during regular use. An eye-level view of the activity (right) is also shown.**

The Scenario: *Sea of Signs*. The following is an imagined impression of what participants experienced during their first session in SMALLab.

Prolog. A brush stroke forms a colored circle in the middle of a soft, white padded mat in a dark space. Within the circle is a subtle, spectral fire that slowly bubbles beneath a large gray nautilus shell. Two people walk in the door. Each one searches the corner of the mat for his or her rug and then drags it into the space. As the rugs move, the colored circle splits into circles, a different color around each rug. Each person moves the rug to the center space, just around the shell, within a couple of reaching distances from each other. They sit down on their rugs and one chooses to start. As they remain silent, they watch small bits of color bubble before them.

SMALLab Setting 1. The first one reaches toward the middle and picks up the shell, bringing it close and holding it firmly in both hands. He moves the wide mouth of the shell close to his. He prepares to speak, but before the words, we hear his breath amplified in the space around him, a peaceful wind that ebbs and lingers.

His voice enters the shell and the environment empathically responds, bathing him in a multi-colored wash around him and leaving a subtle echo as his voice trails away. He pauses to watch the colors fade. He tries again, speaking more, and then seeing more, as he extends his voice into the world for a long soliloquy and an extended pause. He does this one or two more times before he pauses and reaches out to pass the shell to his partner.

His partner tries it. She is more withdrawn and quiet than he was, but more observant with her breath. Her hands feel the shell, and her eyes look to the floor and scan back up to the ceiling, towards the projection mirror, and back down again. She searches the room for the teacher, who sits quietly at the sidelines. Her eyes move back toward her partner and then scan down to the shell she grips in both hands. She closes her eyes, and begins mumbling into it, softly.

SMALLab Setting 2. The partners have now mastered the ritual of bringing the rugs into the space. However, something has changed. As they arrange their rugs and sit down in the space, they notice a thick line connecting them both. At the center of the space, linked to the line, is a picture of one of them. They sit down, and the teacher asks who shall go first. One volunteers to be the first speaker and takes the shell in her hands. The picture changes to be the face of her partner, and then it slides toward the speaker, resting at the foot of her rug—a reminder of who sits before her.

The speaker says a word or two when she notices that the particles now travel towards her partner, the listener. Once she is done with her turn, she passes the shell to her partner. The visual particles follow in a gesture to acknowledge what had been shared: the token flips, and the speaker's face travels towards her partner, to remind her partner that she is there to listen.

Figure 14. **Colors flow from speaking in the shell. On the shell are two reflective markers to track it as it moves.**

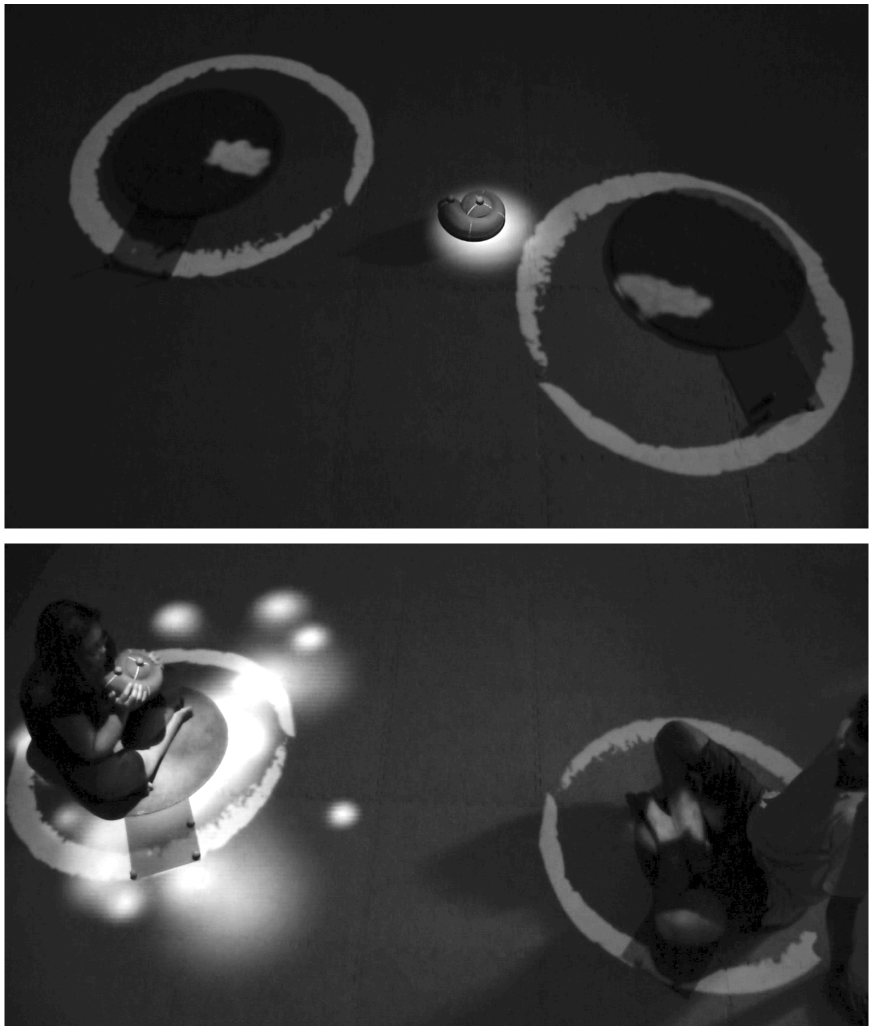

***Figure 15*. SMALLab Setting 1 for *Sea of Signs*. (a) Rugs with rings inside. (b) Sitting on a rug within a circle. Person speaks into the shell, color particles are generated.**

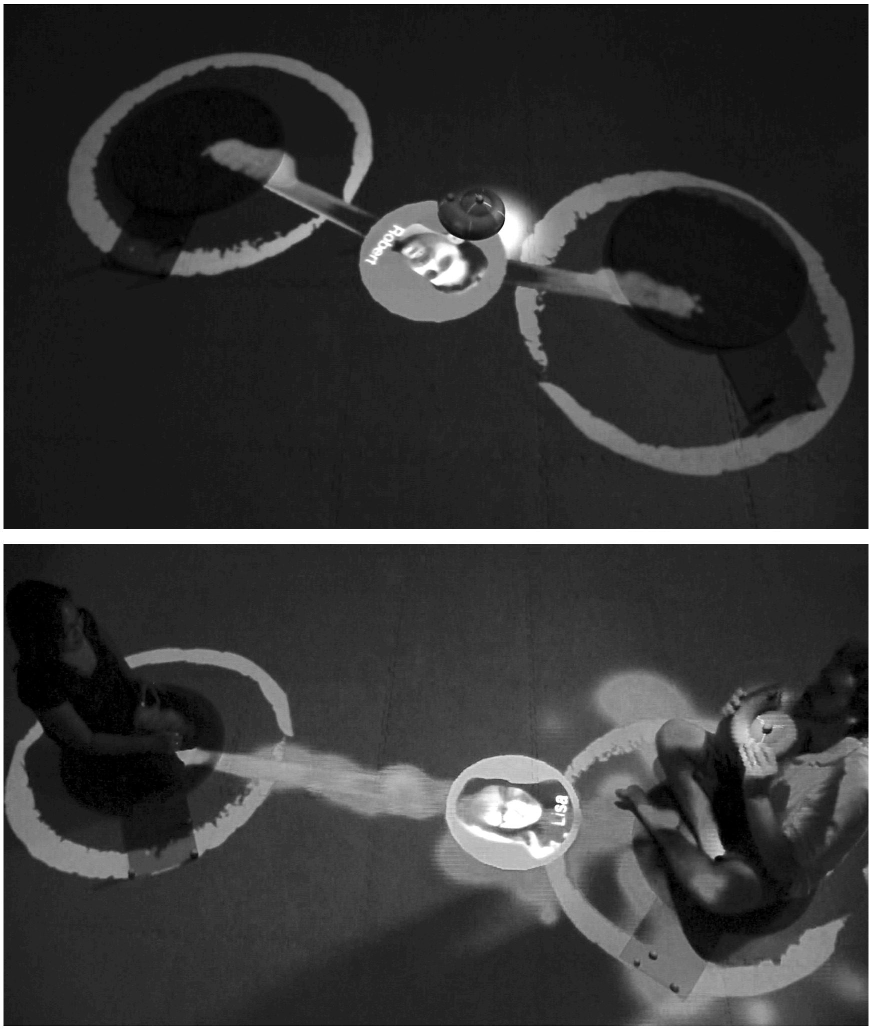

***Figure 16*. SMALLab Setting 2 for *Sea of Signs*. (a) A colored line connects the circles; at the center is a picture that travels back and forth between turns. (b) Person speaks into the shell and color particles travel along the line.**

Flow of vocal signal. A wireless microphone in the shell picks up the speaker's voice. Pitch, loudness, and duration of speech are analyzed, scaled, and streamed in real time to control the color, size, and speed of the particle systems (see Appendix E for more about the system). If pitch and/or loudness data rises above a designated threshold, animated streams of colored particles are dynamically generated in response to these factors. The audio signal is sonically reinforced through subtle amplification and reverberation and then output to the speakers surrounding SMALLab. Together, the audio and visual feedback and large floor display create a spatiotemporal effect driven by a student's voice.

***Figure 17*. Baseline condition for *Sea of Signs*. Participants sit across from each other and speak into the shell. Voice is subtly amplified through surround speakers above SMALLab.**

Baseline condition. The baseline condition, shown in Figure 13, served two purposes. First, it prepared students for coming to SMALLab on a regular basis. Students did not have a pre-existing classroom activity where they practiced speaking to each other aside from speech therapy. To help them become accustomed, the teacher sat down with students in the classroom while it was fully lit and had them engage in the basic interaction: taking turns speaking into the shell and passing it back and forth. As they spoke into the shell, their voices were subtly amplified over two speakers hanging in the classroom.

The second function of the baseline setting was to determine what students would do naturally, i.e., what were their baseline patterns of interaction given the most basic elements (shell, amplification, and teacher presence).

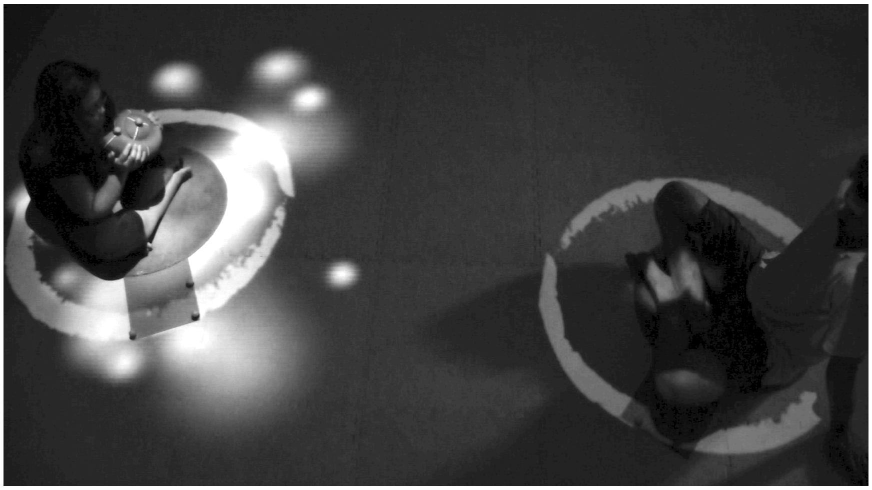

***Figure 18*. Participant speaks into the shell and colors emerge around her in SMALLab 1.**

SMALLab Setting 1. The first SMALLab setting, shown in Figure 14, was used to see if students could make the connection between their voices and its affect on the environment, and if they became more motivated to speak freely of their own volition. In this setting, the lights were turned down, and students pulled and sat on rugs that were motion-tracked in the space. To determine whether they derived a sense of presence and agency in this setting, I looked at the following:

1. Students could autonomously place the rugs and themselves in the space.
2. Students acknowledged (verbally, visually, or with gestures) that speaking into the shell produced colored particles on the floor.
3. The student spoke freely about him or herself.

To determine whether their speaking improved, I also measured:

1. Length of speaking.
2. Ratio of actual speaking length to turn length.
3. The ratio of teacher prompts to spoken phrases decreased.

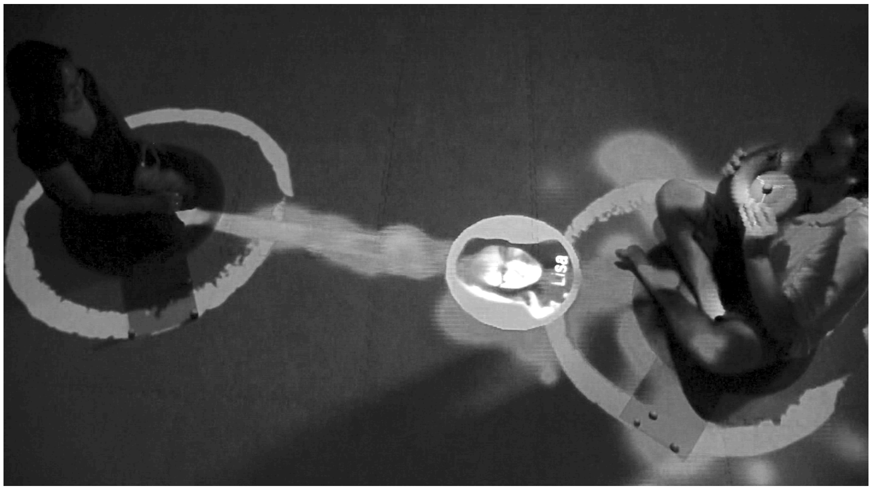

***Figure 19*. Participants are connected in SMALLab 2.**

SMALLab Setting 2. The second SMALLab setting, shown in Figure 15, was designed to direct students to speak to and seek their partners for a response. To determine whether they arrived at a sense of reciprocity with their partner, I looked at whether students referenced their partner more when compared to the previous settings, for example:

- Asked his or her partner a question with decreased teacher prompts.
- Stated the name of his or her partner with decreased teacher prompts.

CHAPTER 5

Data Analysis and Findings

This chapter presents the data and discussion on participants' vocal and/or verbal behavior throughout the experiment. Observations were drawn from three pairs of students, where each pair had a participating student clinically diagnosed with autism. Video coding and analysis focused on the student with autism from each pair. Each student demonstrated different levels of impact from the experiment. Students' speech was analyzed across multiple dimensions to extract the most powerful evidence of change due to the SMALLab environment.

In sum, the data suggests that each student's behavior underwent perceivable shifts in the SMALLab condition. Speech significantly increased for one student. Another student's turn-taking increased even though teacher prompts decreased. The third and final student demonstrated potential to self-express and address her partner in a couple of key moments during the SMALLab condition.

The final data source suggests that both teachers provided anecdotal examples from the regular classroom to suggest that the SMALLab activity impacted two of the three students such that their skills and interest in speaking noticeably transferred back into the class and other areas of their life.

This chapter opens with descriptions of each student's diagnosis and style of social interaction, communication, and problem solving in class, followed by procedures and formulas for coding video and treating data to look for changes in behavioral patterns in the experimental condition (Baseline, SMALLab 1, SMALLab 2). This data is explained and illustrated in a case-by-case format for each student.

Video from each session is coded for:

- **Speech duration.** How timelines were marked in Studiocode[9], i.e., turns, speech, and extracting durations.

[9] Studiocode is a software tool for analyzing and compiling video for qualitative and quantitative research. http://www.studiocodegroup.com, accessed April 7, 2013.

- **Speech-to-turn ratio.** How turn duration ratios were computed, as well as non-turns, and what the calculation looks like. What does a turn look like? Where does it begin/end for each student?
- **Teacher prompting instances.** How teacher prompts were coded (four categories) and then compiled (using merge function) to compute how long teachers prompted for.
- **Emergent self-expression and connection with partner.** How transcripts were analyzed for phrases/topics and categorized based on self-expression and partner reference/interaction. What this revealed for a particular student and why is analyzed in this way (looking for evidence of fringe behavior using Ihde's framework).
- **Transcripts.** For one of the three students, transcripts were made and crosschecked using audio from both the video camera and the shell's wireless microphone.

The analysis methods are followed by the data analysis discussed through the use of comparison graphs and summaries of each student's behavior. The analysis concludes with graphs comparing student trends and a discussion of their similarities and differences. The chapter concludes with anecdotes from post-experiment interviews with teachers, as well as proposals for future areas of investigation and longitudinal study.

Pre-experiment and Typical Classroom Behavior

Teacher profiles. Two teachers, a homeroom teacher and para-educator, were interviewed prior to the 5–week experiment. Both had worked daily in these students' homeroom for at least six years. Each teacher was familiar with their students' typical behavior patterns and provided specific examples of how students verbally expressed themselves and socially interacted.

A para-educator, who will be referred to as *Teacher A*, was in her 40s and held a Master's degree in Educational Psychology. She taught English in second language learning programs abroad for a few years before starting in special education. She had been working with the students in the autism classroom at school for four years. During the experimental phase, she brought students to and from SMALLab and provided support to students during the activity. She is interviewed daily after each full day of baseline and SMALLab sessions.

The homeroom/head teacher, who will be referred to as *Teacher* B, was also in her 40s, had been teaching in special education for 20 years. She started working at a center for youth with multiple disabilities and had developed a system for enabling them to get their needs met while still having fun throughout the day. She moved to the high school district and gravitated toward working with children with autism because the students intrigued her, and she felt an intuitive sense about her ability to work with them.

Student profiles. All students in the classroom who participated in the SMALLab activity received permission from parents. The activity required students to participate in pairs, so the teachers had students retain their weekly speech therapy[10] partner for the full duration of the experimental phase. Of these students, data analysis focuses on three students for whom autism was the primary diagnosis.

DJ in class. DJ is male, age 21. He is rated in the severe autistic range on the Childhood Autism Rating Scale. On the Gilliam Autism Rating Scale, he is at the 107 autism quotient. He has been in the autism classroom with both teachers for the last five years. When Teacher A started working at the classroom four years ago, DJ's typical day had the same general structure as his current day. He participated minimally in morning meetings[11] with his classmates. At the time, he needed constant monitoring and wanted to be alone, making it difficult for him to participate in groups. When walking near him, he would walk away or run and hide under, or at the edge of, something, and he often sought the quiet room[12] to calm down from frustration. Currently, DJ wears industrial headphones to block out noise (Teacher A, Pre-experiment interview-1, p. 10).

[10] For at least the full year and a half prior to the experiment, aside from HH, all students had been attending weekly speech therapy with the same partner.

[11] Morning meeting is a 15–minute period when all students sit together in a half-circle of desks, as the head teacher helps them plan their activities and lunch for the day.

[12] The quiet room is a small, dark, enclosed room with a door that is accessible from within the classroom. The room contains cushions and blankets, where students can go to freely to relax from stress in the classroom.

Teacher B felt that when DJ arrived in the class, he was frustrated not only with the environment and the existing structures in the classroom (schedules, work systems), but that he also did not trust his teachers yet. He would run away from the classroom, tip desks over, throw things, scream, and spit at the teacher (Teacher B, Pre-experiment interview, p. 6).

Teacher B also described a method of interaction that used DJ's imagination. DJ often adopted his persona version of Pegasus at the class morning meeting, so teacher addressed tasks to Pegasus, and then DJ would comply (Teacher B, Pre-experiment interview, p. 11). If we took DJ's enactment of Pegasus as an example of a projective identity—that is, a Pegasus that represents a fusion of characteristics he imagines himself to be, it suggests that DJ has the capacity to revision or re-imagine who he is. He couldn't comply in morning meeting as simply his ordinary self; but as Pegasus, he brings forth his ability to comply. Given DJ's capacity to harness a projective identity, it seems that DJ could benefit from a stronger or extended internal image of himself as someone who communicates and expresses himself more freely and fully using his voice.

Social Interaction (DJ). He still uses the quiet room, but he now participates in one-on-one learning sessions and has grown more comfortable in working with others. His group classes also have point sheets, providing structure that the teacher believes, has helped him participate more. DJ will point out and talk directly to his peers when he notices something needs to be done, e.g., "You need to calm down," or "What's that on your face?" or "What's the big idea?" He's more comfortable in front of a group of people, waiting longer periods of time, and being with peers during leisure[13]. He also takes his headphones off more and more, seeming to tolerate the noise level better in class—and Teacher A wonders if perhaps he wears them out of habit. DJ now consistently attends all his classes, quietly works at his desk, and adapts to incremental changes without problems. His emotional state is fairly even when he has high energy. He works better in the morning and takes more afternoon leisure time (Teacher A, Pre-experiment interview-1, p. 13).

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[13] Leisure period is the last class period of the day, when students are allowed to choose an activity such as reading a book, drawing, playing a video game, exercising, etc.

Teacher B found that she could help establish trust with DJ through pretend play. For example, when she tried to let him know “I have my eye on you,” she pretended to remove her eye and symbolically gave it to him. Even from across the room, she would pretend-throw her eye and he would catch it. Or he would pick up on the teacher’s style and take his own eyeball and throw it to her. When it “fell” once, and the teacher put it back in his eye, he said, “Oh, I can see now.” He also likes to pretend that he’s a Pegasus, so Teacher B uses her keys to pretend-lasso him in (Teacher B, Pre-experiment interview, p. 7–8).

Communication Style (DJ). DJ points out things that are different, wrong, or peculiar, and he communicates frequently. His phrases are often borrowed from movies, which Teacher A believes, come from scenes that are similar to a certain emotion he is trying to convey, such that a phrase or action comes out in a cartoon-like fashion or as Disney clips and singing. For example, he expresses loving thoughts by making a heart sign with his hand, looking around, and performing a *bump-bump* action close to his heart. He is also starting to use more full sentences that are less cartoonish. He is responsive to one particular student in the classroom who initiates and starts more conversation within DJ (Teacher A, Pre-experiment interview-1, p. 11).

Regarding echolalia, when he is “having trouble” expressing how he feels, Teacher B will feed him words from his perspective. For example, she says, “I feel …” instead of asking, “How do you feel?” He then repeats her words – “I feel” – and fills in the blank (Teacher B, Pre-experiment interview, p. 12).

Problem Solving (DJ). DJ actively seeks out solutions for himself before asking for help, so they must constantly remind him not to do things. For example, if something smells, he may open up the teacher’s cabinet and finds something to spray it with, saying, “Oh, that stinks!” He looks to the teacher for attention, and he tests the teacher’s limits in playful ways, trying to find the barriers. If DJ is trying to concentrate and someone bothers him or invades his space, he will get anxious and say something.

When DJ wants to use the quiet room to get away from the classroom noise, if the room is occupied, he just stands there waiting for a teacher to help him. However, when he notices that

Teacher B or a peer needs help with something (e.g., peers have trouble with writing lunch options), he will say something or try to help them directly, like writing down options for his peers).

EM in class. EM is a female, age 19. She is identified as having Autism/MIMR[14] in the severe range. Her characteristics fit well with autism. She has limited/preferred activities that she focuses on or she likes to talk about, and she counts in a natural rhythm (Teacher B, Pre-experiment interview, p. 43). Once she learns something, she has a hard time deviating from it, so the teachers always plan for flexibility (Teacher B, Pre-experiment interview, p. 45).

EM has been in the classroom for at least the last four years. She is attentive in the morning, has independent work, and is in a communication skills class where they play language games and encourage interaction and discussion. She mainly likes to sit by herself with a different doll she brings in each day; however sometimes, she will draw or read a Disney book. She seems to have what the teacher calls a “database” of all country singers and their songs in her mind, and she will think of a song that is attached to a person. She loves interrupting people to talk about the thing she wants to talk about all the time. She often talks about shopping and food all day long.

In class, she diligently spends most of her time doing class work, which typically involves cutting, pasting, writing, and reading comprehension, which she is very good at. In the last three years, she has developed her reading comprehension such that she pays much better attention in class and sometimes blurts out answers when it is not her turn. She will be accurate with answers such as the current date or subject the class is studying (Teacher A, Pre-experiment interview-2, p. 13).

Social Interaction (EM). EM does not initiate conversations with peers; however, she responds to other people who talk to her. If a peer says, “Hi” to her, she will say “Hi” and their name back to them. If a peer asks her a question, she will produce an appropriate one-word

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[14] MIMR is the acronym for Mild Mental Retardation, which, According to the Arizona Revised Statute (ARS) § 15–761 (12), means “performance on standard measures of intellectual and adaptive behavior between two and three standard deviations [determined by professional evaluations] below the mean for children of the same age.” Individuals with mental retardation may develop social, emotional, academic, and physical skills more slowly. Definition referenced at website http://www.susd12.org/node/471, accessed on March 20, 2013.

answer. She does walk up to the teachers to say, “Shopping.” A teacher would then say, “Can you make a sentence?” EM will blurt out one word, after which the teacher asks again, “Who are you talking to?” After which, EM will remember to address the teacher with, “Miss so-and-so.”

EM is okay with taking turns, but when it comes to volunteering, she will try to jump ahead and take her turn. She will speak for others. When it is someone else’s turn to say the answer, EM does not wait—nor perhaps realize, that it is another person’s turn to talk (Teacher A, Pre-experiment interview-2, p. 14). EM also has a distance about her. She connects with teachers but has only recently started to connect with her peers. For example, she now walks over and grabs their hand (Teacher B, Pre-experiment interview, p. 46).

Communication Style (EM). Currently, she is fairly definite about what she wants. For example, if Teacher A asks her, “Would you like to play a game? Would you like to read a book?” She quickly responds with, “No, thank you.” Whatever is on her mind will come out vocally, in repetitive phrases, like a broken record. When Teacher A politely interrupts her, EM changes the subject and will immediately start asking the teacher about the new subject, such as shopping (Teacher A, Pre-experiment interview-2, p. 13).

When Teacher B asks her questions about how she feels, she’ll say, “Happy. Happy about shopping,” and the teacher will try to expand, saying, “Shopping at?” Often times, she will turn her head to the side, so Teacher B copies her—which captures EM’s attention in the sense of “What are you doing?” Teacher B believes there is a lot going on in EM’s head that she wants to communicate. She gets excited about things and you can see her thinking. When EM is experiencing echolalia, the teachers write it down and she reads. When she talks during class, they start her off with a full written sentence to help her remember the words and increase her sentence length (Teacher B, Pre-experiment interview, p. 45).

When EM communicates with others, she will sometimes “jump the gun” when she should be listening to her partner’s answer; i.e., she will produce her own answer to the question (Teacher A, 4.25–2, p. 6–7). She also repeats topic words louder and more frequently when she wants to communicate something (p. 7).

Problem Solving (EM). EM used to demonstrate frustration by pinching or hitting other people or slapping her own face. Now she will say, “No hitting EM.” During one week, the class went shopping and the teacher changed the rules to be that EM could only buy one thing now to save money for things the following week. EM persisted in saying, “Two,” with the teacher then saying, “Nope, just one.” Finally, EM says, “No hitting EM,” with the teacher’s response being, “Yep, there’s no hitting Nicole,” as they came into agreement (Teacher B, Pre-experiment interview, p. 46).

HH in class. HH is female, age 17. HH joined the autism classroom at the beginning of the academic year. HH is identified as having Autism in the severe range as well as a seizure disorder. On a typical day, she follows her complete schedule and has trouble adjusting to new routines but can manage them once she gets comfortable. Food and snack seems to motivate her to come into school; and after morning snack, she is cheerful, compliant, and follows her schedule. Although she is cheerful in the morning, she gets tired in the afternoon and looks for a place to lie down. She likes busy work and has a hard time staying in the leisure room during leisure time. She rushes through work, even if it is more challenging, and has become more honest about completing her work correctly and asking for help (Teacher A, Pre-experiment interview-1, p. 6). She really likes structure but likes being in charge, and when her internal clock is not working, she misses things like the bus (Teacher B, Pre-experiment interview, p. 57).

Social Interaction (HH). HH loves to wave at people she’s never met before (Teacher A, 4.25–2, p. 9). Sometimes HH makes direct eye contact with others and can be very social, uttering words like, “Hello” and “Hi.” She seems to understand what is said, but the teachers are not quite sure how much time it takes her to fully comprehend information. She is very bright, catches on to a routine, and is at least at a second grade reading level with lots of vocabulary. She came from a classroom that allowed her to do a lot of independent computer work. Teacher A thinks that her having had so much independence has made it challenging for her to take direction from new teachers, who have to do a lot of warming up to build rapport with her. Each day, she becomes calmer and more familiar with classroom structure (Teacher A, Pre-experiment interview-1, p. 5).

During leisure time, which lasts 10–15 minutes, she can get bored and will want to visit another classroom to be more social. The teachers do not necessarily see this as detrimental, but they want her to follow the rules of what the teacher says. So Teacher A begins reminding her of puzzles in order to help HH stay in leisure longer (Teacher A, Pre-experiment interview-1, p. 6).

Sometimes, HH sees her peers talking to each other, and she becomes curious and tries to join. However, when the teachers encourage it, she refuses, as she has a tendency to do the opposite of what they suggest (Teacher A, 4.25–2, p. 8–9).

Communication Style (HH). HH knows everyone's names. She may easily walk up to someone, reaching up and communicating by touching hands and fingers and making eye contact and saying their name. A couple of times, the teacher has heard HH say, "Hello" and their name. When she sees Teacher A in the morning, she may approach the teacher as if to greet her with what the teacher refers to as "a sparkle in her eyes," however, instead, she might point and say, "Chicken sandwich." The teacher believes that HH's verbal expression could be more of a symbolic or associative phrase corresponding with what HH might be thinking, i.e., "Good morning," rather than what is actually expressed, i.e., "Chicken sandwich" (Teacher A, Pre-experiment interview-1, p. 4).

Because HH uses touch to communicate, and there is a "no touching" rule in class, the teachers encourage her to practice saying "Hi" or a person's name. When HH hears directions, she often echoes the last word or last few words of the phrase. This suggests to the teacher that HH needs extra time to process the meaning of the phrase. When communicating with peers, she uses eye gaze and single words that she repeats back. In anticipation of an activity, she will raise her hand or jump ahead to help a teacher with setup to indicate she is interested in participating (Teacher A, Pre-experiment interview-1, p. 7).

HH also uses visuals for receptive communication, such as showing you a picture of something in order to receive reassurance. She is still learning the classroom routines but reads everything and will also points things out. For example, Teacher A may say the same thing every day, or turn off the music to cue a transition to the next activity, and she says, "Alright." She repeats everything the teacher says, i.e., there is echolalia, though her speech can be choppy and tense. HH is also more likely to respond to directions that are shorter phrases or words, such as “Basket” instead of “Go get your basket.” When she gets confused or is in disagreement with a teacher, she throws a tantrum and goes, “AAAAAH!” loudly, or she sits down on the ground, at which point, the teacher backs off and HH quiets down (Teacher B, Pre-experiment interview, p. 53–5).

Problem Solving (HH). HH does not like to be helped and prefers independence and doing things on her own (Teacher B, Pre-experiment interview, p. 53). She also performs much better with visual (versus vocal) prompts. Visuals, such as reminders of consequences, seem to provide a clearer meaning for HH to process. Early in the academic year prior to the experiment, HH resisted verbal instructions and would scream and throw temper tantrums when teachers tried to direct her (p. 53). For example, one morning, a teacher said, “backpack goes there,” HH stomped and looked away and repeated the last word in the phrase in an echolalic manner. They believe she may have difficulty processing spoken instructions, so the teacher started writing messages for her by hand. HH became much quicker to do the written tasks and commands when compared with vocal instructions. HH learned the point system well, and teachers used visuals, such as a “time out” sign with arrows and a countdown (Teacher A, Pre-experiment Interview-1, p. 3).

Teacher A has noticed that when HH does not understand what is expected of her or is confused, she signals this by halting what she is doing, getting up, and refusing to come back to continue working (Teacher A, 4.25–2, p. 8).

For leisure, she has a difficult time because there is nothing she really likes to do there, so she will sit down in a chair next to the teacher and wait (Teacher B, Pre-experiment interview, p. 57). But she sometimes likes to choose puzzles and a matching memory game, as well as Velcro-based activities that do not require her to write (she has physical difficulty guiding her hands). However, she needs the teacher to remind her of what is available. Teacher A will sometimes list items and pause between each one, which gives HH time to redirect herself, go back to the leisure area, and give her choice another try. Teacher A senses that if an item is not in HH’s visual field regularly, then it might not cross her mind. For example, if HH has a task that involves completing step-by-step work on page 1 and then folding over the page to complete the next step on page 2, she can do it when she sees other students do it. However, if she is alone, she gets frustrated and expresses it by making a sound, clenching her hands, and flipping pages (Teacher A, Pre-experiment Interview-1, p. 4).

Data and Analysis of Behavior during Experimental Phase.

Methods of coding and analysis. In the analysis, I looked for evidence to suggest an emerging trend or change in student's behavior patterns between the baseline condition and the SMALLab conditions. Each session was videotaped and coded as instances to derive elapsed time for the following:

a. A student taking a turn refers to:
    1. Student either holding the shell close to or toward his/her body (i.e., not pushing it away or offering it to their partner).
    2. Student actively responding when teacher holds the shell microphone facing student's mouth in preparation to speak.
b. A student speaking or uttering any sound except for a laugh.
c. The teacher prompting either student verbally or physically. Prompts were logged for each session in their entirety rather than per student (rationale is that a student receiving a prompt is itself a modeled behavior that serves to prompt the other student).
d. Teacher actions classified as prompts included:
    1. Guiding students' physical behaviors or orientations, e.g., by helping the student hold the shell with both hands, by turning a student's body or head to face his/her partner.
    2. Offering topics by handing the student a topic card or asking a direct question, e.g., "What's for lunch?" or pointing to the colors projected on the floor to draw students' attention to it;
    3. Asking a student to take a turn, e.g., "Would you like to tell the shell?" or cupping her hand to her ear; and,

4. Directing the student to speak to his/her partner, or for example, saying “Could you tell (your partner) about what you’re having for lunch today?”

Each coded instance has a duration, which was treated as first order data. Coded instances were converted into second order data by normalizing them into percentages (or ratios) before they were plotted and compared with other durations. This second order data was calculated by dividing the duration of interest by the elapsed time in which it occurred, yielding a value from 0–100% or 0.0–1.0. For example, second order data on the total time a student spoke in one session was calculated by summing all instances of the student’s speech for that session and dividing the sum by the total session length.

Students had three or more sessions each in the baseline, SMALLab1 and SMALLab 2 conditions. Median data across sessions for each condition was used to provide a look at possible emerging trends. The analysis explored central tendency through median values in order to alleviate the effects of outlier data on the smaller number of sessions.

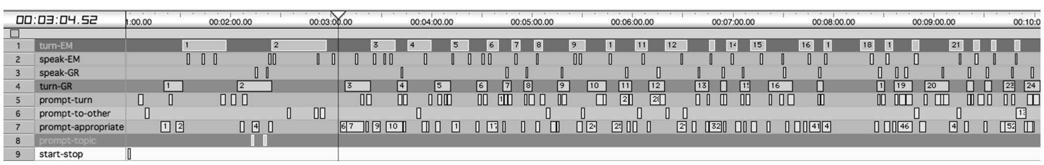

***Figure 20*. Studiocode timeline example for a single session.**

Figure 20 shows a fully coded timeline for a single session. Figure 21 shows a close-up of the codes. Each student’s *turn* and *speak* instances fall into unique rows (#s 2–5) labeled “turn” and “speak,” and have a duration block and instance number. Each “speak-” instance was tagged with “with shell” or “no shell,” to indicate whether the spoken instance occurred while the student was taking a turn (holding the shell) or not. Teacher prompts were coded using four labels prefaced with “prompt-,” and each also had a duration block and instance number (rows #s 7–10).

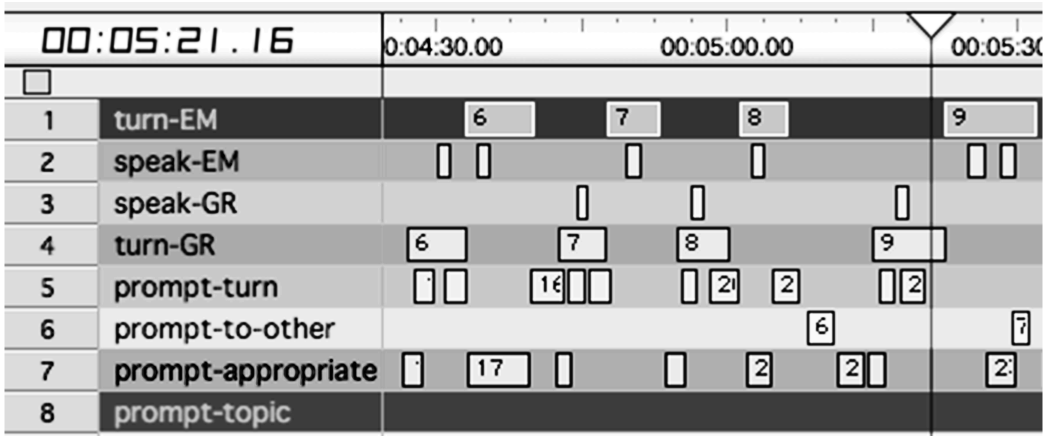

***Figure 21*. Studiocode timeline with close-up of the timeline codes and duration instances. The elapsed time is formatted in hours:minutes:seconds (HH:MM:SS.00).**

The following calculations were performed to generate data plots.

(1) Total speech duration per session as a percentage: For each session, all of a student's speech instances were summed and divided by the total length of the session. This measure describes how much of the session a student was speaking, both in-turn and out-of-turn.

Sum(SpeechInstanceDuration) / SessionDuration

(2) Total turn duration per session as a percentage: For each session, all of a student's turn instances were summed and divided by the total length of the session. This measure describes how much of the session a student was taking a turn (possessing the shell).

Sum(TurnInstanceDuration) / SessionDuration

(3) Total speech duration occurring during turns in a given session, as a percentage: For each session, all of the student's speech instances that occurred during a turn were summed and divided by the total elapsed time for all turns. This measure describes how much of a student's turn time he/she used speaking.

Sum(SpeechInstanceDuration_withShell) / Sum(TurnInstanceDuration)

(4) Total speech duration occurring between turns in a given session, as a percentage: For each session, all of the student's speech instances that did not occur during turns were

summed and divided by the total elapsed time in which turns did not occur. This measure describes how much session time a student was speaking out-of-turn (i.e., without the shell).

Sum(SpeechInstanceDuration_withoutShell) /

[SessionDuration – Sum(TurnInstanceDuration)]

(5) Ratio of speech to turn duration, per turn: For each session, a student's speaking instances were marked "with shell" when they occurred during a turn. For each turn, these speech instances were summed and divided by the length of the turn in which they occurred, yielding a ratio value (0.0–1.0) of speech for that turn. This measure describes the percent of time that a student spoke during a single turn, in a given session.

For each Turn_n:

Sum(SpeechInstanceDuration_withShell) / TurnDuration

(6) Ratio of non-turn time that is speech, per session: For each session, a student's speaking instances were marked "without shell" when they occurred in the period that was not their turn. This period is termed as a non-turn. For each non-turn, these speech instances were summed and divided by the elapsed time between the end of the previous turn and the beginning of the turn that followed, yielding a ratio value (0.0–1.0). This measure describes the percent of time that a student spoke during the time between two turns, in a given session.

For each *NonTurn*, where speech occurs:

Sum(SpeechInstanceDuration_withoutShell) /

[BeginTime(Turn(n+1)) – EndTime(Turn(n))]

(5) Median ratio of total speech per turn, per session (as a percentage): Using formula # 3 to calculate each SPEECH:TURN ratio, the median value of all SPEECH:TURN ratios for one session is calculated. This measure describes the central tendency toward speech during turns for a specific session.

(6) Median ratio of total speech during non-turns, per session (as a percentage): Using formula # 4 to calculate each SPEECH:NON-TURN ratio, the median value of all SPEECH:NON-TURN ratios for one session is calculated. This measure describes the central tendency towards speech between turns for a specific session.

(7) Median ratio of turn-based speech per session, per condition (as a percentage): By plotting the SPEECH:TURN ratios for all sessions, the median is calculated for each set of sessions per condition. This measure estimates overall central tendency for speech during turns across sessions in a specific condition.

(8) Median ratio of non-turn-based speech per session, per condition (as a percentage): By plotting the SPEECH:NON-TURN ratios for all sessions, the median is calculated for each set of sessions per condition. This measure estimates overall central tendency for speech during turns across sessions in a specific condition.

(9) Difference in central tendencies between turn-based and non-turn-based speech: The difference between formula #s 8 and 7 estimates how much more turn-based speech occurs versus non-turn-based speech.

(10) Overall teacher prompt duration per session: All instances marked as a prompt are merged in Studiocode. This yields a composite duration that accounts for overlapping prompt durations and prevents time instances from being counted twice.

Each student's data will be presented in a case-by-case analysis, followed by a comparison of all three. Each analysis begins with a student profile derived from teacher interviews, followed by discussion about the student in each condition. For each student, there are five line graphs. Four of the graphs have session numbers placed on the X-axis, and percentage durations or ratios of specified time are on the Y-axis. Each point on the graph summarizes a single session at that point, and a break in lines is used to demarcate a set of sessions in one of the given conditions—baseline, SMALLab1, and SMALLab2. The fifth graph has three points, with each point representing a summary of all sessions in one condition. Conditions are listed on the X-axis, while the difference in values between turns and non-turns are listed on the Y-axis.

For student HH, an additional chart shows a rough summary of words and phrases spoken during her sessions. The chart is there to expose moments in SMALLab where self-expression and acknowledgment of others occurred to show that AT was able to produce expressions not wholly based on concrete topics provided by the teacher. Further investigation and analysis is necessary, however, to make solid inferences from the content of her speech.

DJ Trials

Baseline (DJ). During the Baseline sessions, predictable communication and behavior patterns emerged for DJ. In every session DJ talked about all his many toys, the Pegasus (the imaginary winged horse) and “shopping at eBay.” He would read topics of cards provided by the teacher. He also tickled and touched his partner’s feet in a teasing, playful manner, who laughed and sometimes pushed DJ’s arm away. His partner was much less vocal and quiet in her response, so Teacher A interpreted this behavior as “his desire to see a reaction and communicate non-verbally” (Teacher A, 4.25–2, p. 3). DJ rarely asked questions of his partner or spoke directly to her. Rather, he seemed to prefer speaking to or for himself, appearing “a little bit delighted when papers were presented on the floor with possible things to talk about,” and speaking “as if he was talking all to himself about his favorite things” (p. 3). DJ would, however, quickly comply with the teacher by repeating what she prompted him to say, such as addressing his partner. Without the prompts, he still continued talking about his personal interests.

DJ’s collection of common phrases included: “grunkel,” “so many toys,” “shopping at eBay today,” “how to train your dragon,” or he would speak about Pegasus or movies. During some of his turns, he used an announcer voice to say: “Ladies and Gentleman, Welcome!” DJ also spoke more often to request his turns by saying, “Shell, please.” In all sessions, when it was DJ’s turn to speak into the shell, he would first take off his headphones. When he finished using the shell, he would hand it to his partner and then put his headphones back on.

SMALLab 1 (DJ). In the first SMALLab 1 condition, DJ had an immediate response to the environment. DJ seemed to notice the colors that emerged from his circle and looked around at them, saying, “Wow, these colors are so amazing!” He integrated this phrase repeatedly throughout his turn. After the first couple of sessions, he required no prompting to start the activity; he quickly pulled his rug onto the SMALLab floor and placed it opposite from his partner (p. 1). He even began to pull his partner's rug onto the floor as well, adjusting and positioning it opposite his own, indicating enthusiasm for the experience.

Though DJ was beginning to speak comfortably on his own, Teacher A observed that he needed 2–3 prompts per minute to focus his attention on his partner (Teacher A, 5.08, p. 1). Whereas in Baseline, DJ relied on the cards to generate material, in the SMALLab 1 condition, DJ seemed to become more comfortable talking about topics such that Teacher A could remove the card and DJ would continue to bring up the idea in future turns. He also started to say his partner's name on his own, just before or right after he read a card or asked a question.

SMALLab 2 (DJ). At the beginning of every session, DJ rapidly positioned the rugs on the SMALLab floor on his own (Teacher A, 5.11, p.1). In this condition, when a photograph of his partner's face appeared on the floor when it was his turn for the first time, DJ said his partner's name and directed his questions toward her (p. 1–2). On seeing his partner's face, he remarked, "[Partner], is that you?" On seeing his own face: "Thank you for the new headphones, [Teacher B]," followed by, "Oh, well these amazing colors, I can't just pick one," as colored particles surrounded him on the floor (5.11, p. 2). The faces appeared to prompt DJ to use his partner's name and speak directly to her.

Unless directed by the teacher, DJ usually started each session, grabbing the shell and independently generating something to say. He usually began with a soliloquy about shopping on eBay, "pictures today," toys, and fantasy or movie-based topics from previous sessions. He would also mention some phrase or topic that Teacher A connected to an event or instance that recently occurred in class (5.11, p.5). Though the teacher would move the prompt cards around between the students, DJ could still recall the topics and start the conversation, saying "Well, what are you having for lunch today? What did you have for breakfast this morning" (p. 2)?

For DJ's 15th session, the teacher chose to remove printed material altogether, because she "wanted to see the truth about how they can interact using the shell and not spend time reading material … without the security blanket of being told what to say" (Teacher A, 5.11, p.1). She found that DJ continued to incorporate his partner's name into what he was saying. When he finished talking, the teacher prompted his partner to take a turn. During her turn, DJ appeared focused on her, patiently waiting for her to finish speaking without fidgeting or anxiously moving around.

He also prompted her on his own, continuing to ask her questions based on previous topics. For example, he would say, "What did you have for breakfast, [partner]?" "[Partner], what are you having for lunch?" "Great idea, [partner]," "[Partner], say something," (5.11, p. 3) or ask her a question about shopping (5.18, p. 27). At one point, he inched his rug closer, leaned into her circle, and assisted her with speaking into the shell (5.11, p. 3). It could be that he was motivated to encourage her to speak because he wanted to see her generate streaming colors from her circle, i.e., to heighten his own experience rather than enrich that of his partner.

Discussion (DJ). Overall, DJ's fluidity with speech increased and grew with the introduction of SMALLab. Each point in Figure 22 shows the percentage of each session that he spent speaking and holding the shell (taking a turn).

In the Baseline condition, his speaking time averaged 34.5% per session. In SMALLab 1, DJ's speech time averaged 58.6% of the session. In SMALLab 2, his speech continues to rise, with a mean of 61.6%.

Juxtaposing his turn-taking with his speaking times, in the Baseline condition, DJ consistently spent more time holding the shell with less speech, which can be seen where the speech plot (solid line) falls below the turn-taking plot (dotted line). In SMALLab, however, DJ would sometimes speak out-of-turn, which is shown where the speech plot exceeds the turn-taking plot. This suggests that although DJ would use his turns to speak, he also continued to express himself outside of the SMALLab turn-taking framework. A subset of his expressions also included his attempts to prompt his partner to speak.

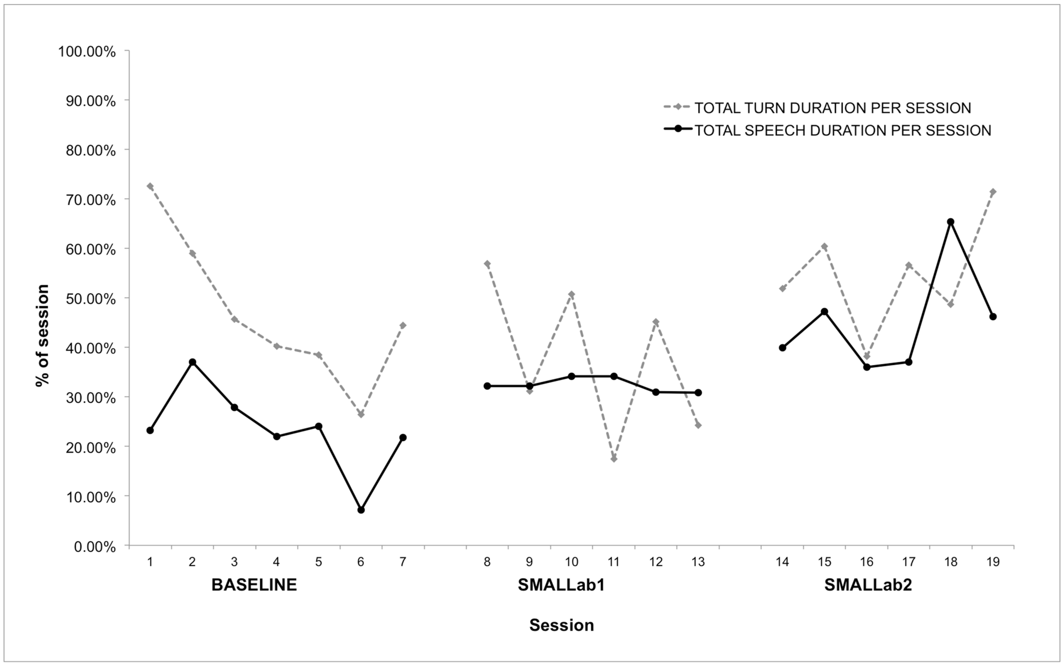

***Figure 22*. DJ's comparison of percent of elapsed time speaking and turn-taking. DJ's total speech duration per session (solid line) vs. total turn duration per session (dotted line), across all sessions. Each point represents the duration as a percentage of session time.**

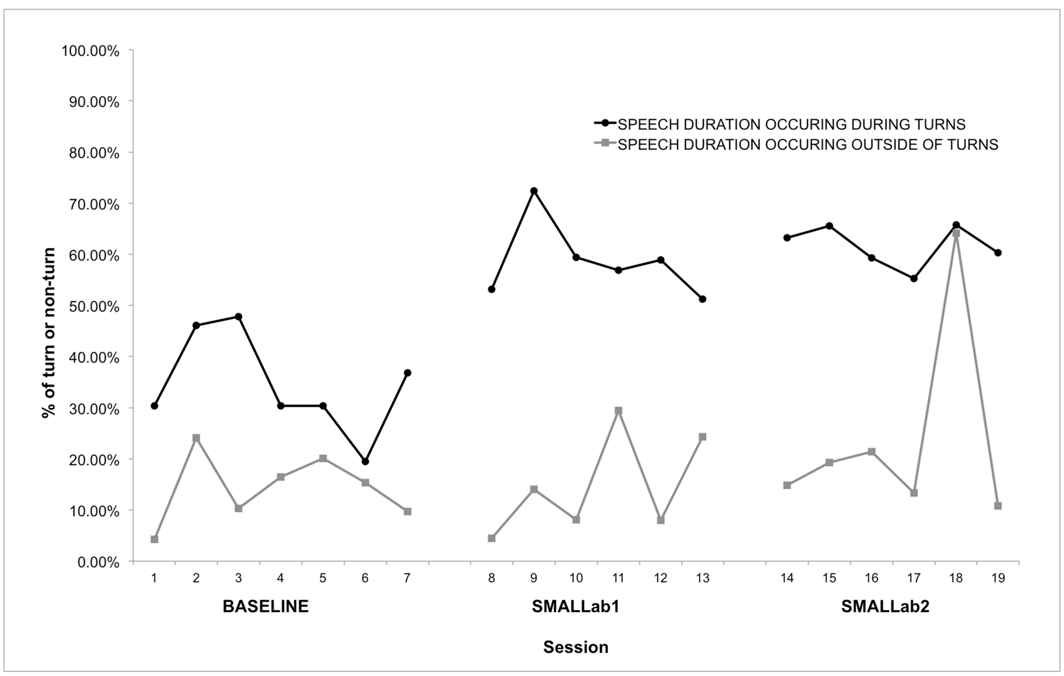

***Figure 23*. DJ's comparison of percent of elapsed time speaking during turns. DJ's comparison of all speech that took place during turns (using shell) versus all speech that occurred outside of turns (not using shell).**

Figure 23 compares the percentages of overall expected speech (speech during a turn) vs. overall unexpected speech (speech during a non-turn) and normalizes the values using the overall time in which they occur. For example, Session 4 indicates that DJ was speaking for about 30% of his total turn time; however, he continued speaking for 15% of the time outside of his turn. During the Baseline condition, DJ's tendency to speak during turns considerably fluctuated (between 20 and 50%), as did his tendency to speak outside of turns (between 5 and 15%). However, in both SMALLabs, the amount of speech DJ produced during turns jumped to a range from 50 to 75% and remained there. His speech in between turns, however, falls within 10 and 20% of his non-turn time, with a spike in the 18th session. Given the history of this student, the spike could have been the result of external effects, such as DJ having a high-energy day in general.

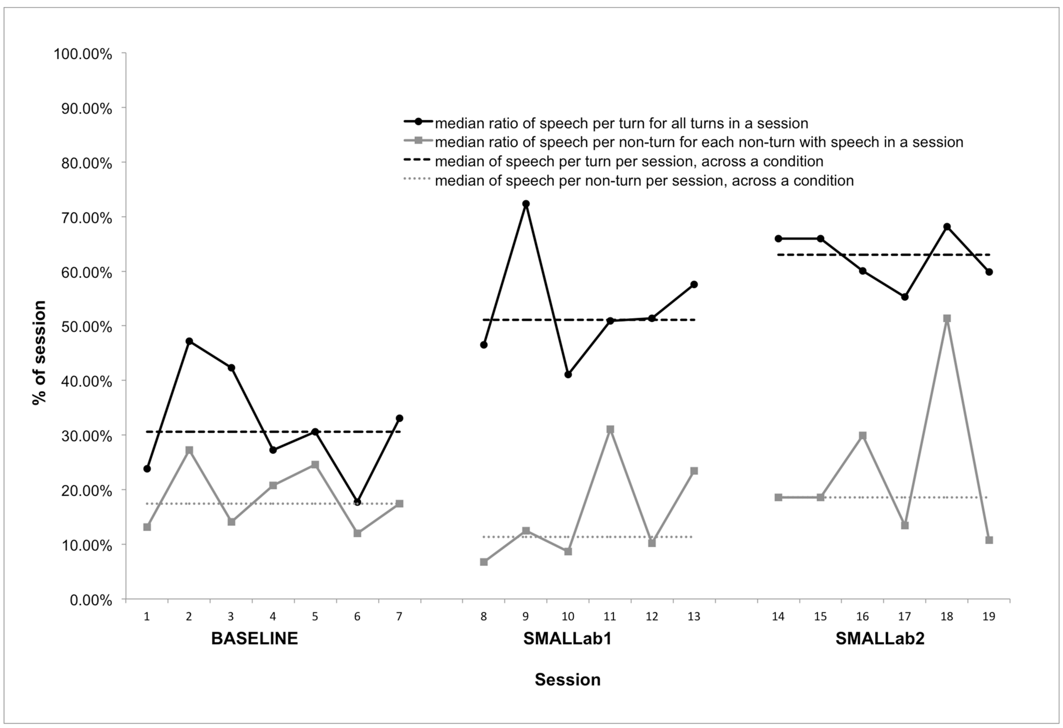

***Figure 24*. DJ's comparison of median ratios of speech during a turn vs. out-of-turn. DJ's central tendencies for speaking with vs. without the shell, per session. Horizontal lines show the median central tendencies for each set of sessions in a given condition.**

Figure 24 shows third-order analysis of turn-based speech and non-turn-based speech as an attempt to explore speech trends across conditions. Each circle-shaped point represents the median percentage of speech across all turns in a session, i.e., what was DJ's tendency toward speaking during any turn, in a given session? Each square-shaped point represents the median percentage of speech between turns in a session, i.e., what was DJ's tendency toward speaking in between turns, in a given session? Though Figure 23 and Figure 24 look similar, medians (versus raw overall percentages) were used to produce the Figure 24 plot. In addition, non-turn instances (time period between turns) were only counted where speech was actually present.

Comparing medians across conditions, the graph indicates that the amount of non-turn-based speech did not change across conditions. However, the amount of turn-based speech jumped almost 20% between Baseline and SMALLab 1, and it jumped an additional 10% from SMALLab 1 to SMALLab 2. This suggests that DJ may have been more compelled to speak longer and more frequently during his turns, saturating his turn with more speech and decreasing the length of his pauses when stimulated by the multimodal experiential environment, and that the structure designed into the SMALLab environment did guide DJ towards preferential communication patterns.

Figure 25 illustrates this phenomenon by comparing the difference in tendencies. At Baseline, tendency toward turn-based speech was only 13% greater than non-turn-based speech, whereas in SMALLabs 1 and 2, tendency toward turn-based speech was upward of 40% greater than Baseline.

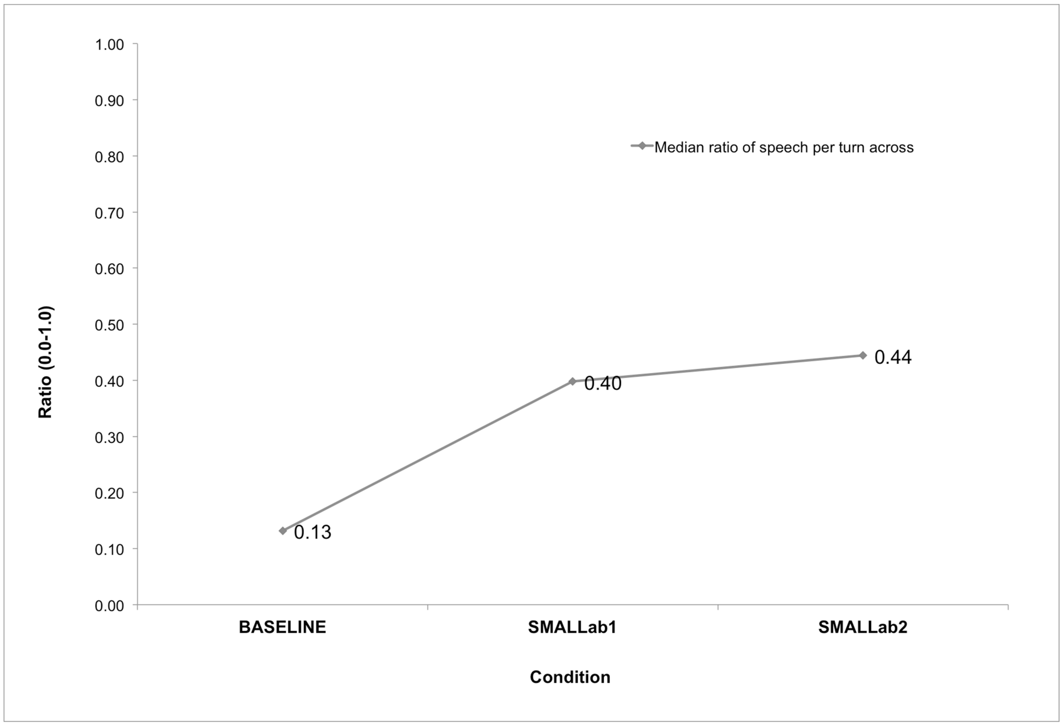

***Figure 25*. Difference in medians between speech during turn and non-turn. DJ's difference between the median speech ratios of speaking (a) during turns and (b) between turns, i.e. (a) - (b).**

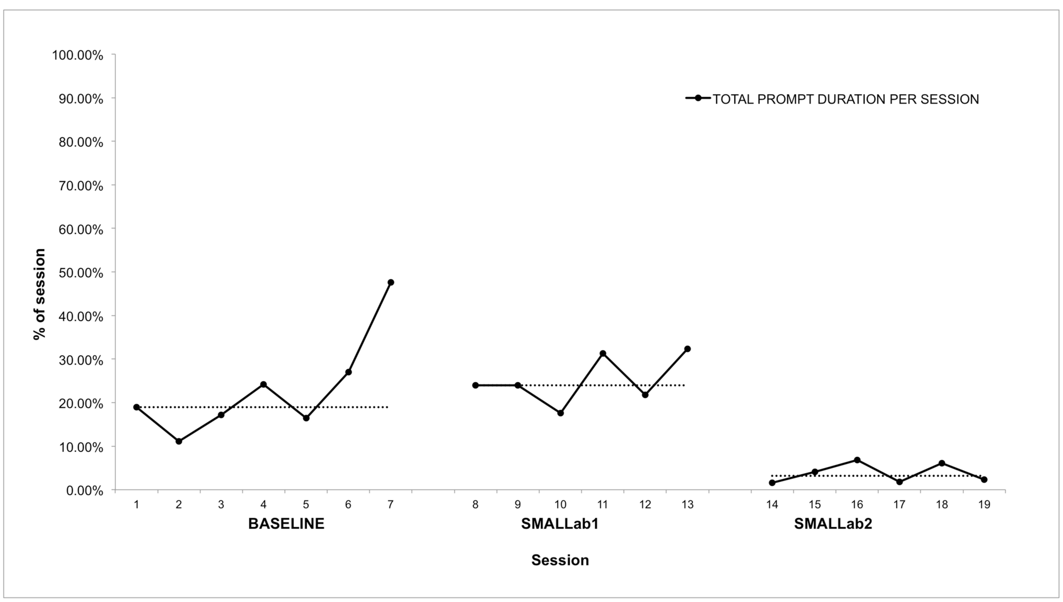

***Figure 26*. DJ's percent of each session with teacher prompts. DJ's percentage of each session during which the teacher prompted him or his partner.**

In Figure 26, each point shows the percentage of the session during which the teacher prompted one or both students. At Baseline, the median percentage of teacher prompts is approximately 20% of the session duration. It increases slightly during SMALLab 1 and then drops below 5% during SMALLab 2. This suggests two possibilities. The first possibility is that between Baseline and SMALLab 1, the teacher was necessary to provide topics and demonstrate the appropriate social interaction protocol for each distinct environment. However, by SMALLab 2, the interaction protocol was well rehearsed and/or clear enough for DJ to respond appropriately, or that the design approach increasingly supported and encouraged direct conversation in DJ. Also noteworthy is that even though teacher prompting dropped in SMALLab 2, DJ's speech and turn-taking tendency increased.

Given DJ's disposition from the qualitative description and his general desire to be independent, having less teacher presence enabled DJ to better focus on receiving feedback directly from SMALLab, allowing him freedom to produce his own speech at his own pace.

Summary (DJ). In summary, SMALLab 2 data indicates that DJ increased his overall speech per session by 27% from Baseline (see Figure 22), with 31% more turn-based speech (Figure 25). This occurred as teacher prompts decreased from 19% per session at Baseline to 3% in SMALLab 2.

HH Trials

Baseline (HH). During Baseline sessions, HH would actively pick up and read the topics on the cards the teacher provided. However, when reading the cards, she focused on answering the teacher, i.e., there was minimal interaction between her and her partner (Teacher A, 4.25–2, p. 8). Her preferred topics included her favorite snacks or lunch at school. When the teacher verbally prompted her (without cards), she sometimes replied directly into the shell, and other times she replied without it. HH was also typically seated in close proximity to her partner. When the teacher prompted her to ask her partner a question, she occasionally held the shell up to her partner's face, looking at her and repeating the teacher's question.

To signal that she was done with the activity, she would abruptly stand up, walk towards the row of chairs at the side of the room, sit down, and put on her shoes (p. 8). Within a minute or two, her partner also seemed to take cue, standing up and then walking over to the chairs. In this way, HH's physical action of sitting down or getting up marked the beginning and ending of sessions. Furthermore, if Teacher A asked her to do something, she sometimes refused by lying down or pushing the shell away. This is consistent with what teachers described about her behavior and desire for independence in class.

HH seemed curious about the sound the shell produced, noticing that if she tapped or shook it, the sound was amplified over the surrounding speakers. As a result, she would often shake or aggressively tap the shell on the ground.

SMALLab 1 (HH). In the first SMALLab session, the teacher helped both students drag their rugs onto the floor to prepare for the activity. At this time, and at the beginning of each SMALLab 1 session, HH's eyes were drawn to the small cluster of moving particles that were displayed by default in each ring. She would walk over towards them, tap them with her hand, and lay down directly on them. This signaled the beginning of the session, at which time, the teacher would join in and begin offering the shell to them. A couple of times, HH grab the shell on her own, say something into it, and then put it down immediately before lying down.

In the first SMALLab session, HH did not seem to notice that speaking into the shell generated color streams. This could be because her vocals did not rise above a minimum length and duration of speech required by the system, thereby preventing the colors from being produced. A quick adjustment was made at this time to lower the threshold so that colors would appear when she spoke. In addition, because she would lie down on the floor with her face looking up, it is possible that she did not realize there were colors around her. Rather, she may have been focused on the colors projected in the ceiling mounted mirror. However, once she sat up, and her partner's speech triggered the colors, HH appeared startled and immediately jumped up, swiftly walking off the SMALLab floor and sitting down in a chair to the side of SMALLab. As she sat on the sideline, she still answered the teacher's questions and watched the colors on the floor. This happened during two sessions in the SMALLab 1 condition.

While HH laid on the SMALLab floor, she would sometimes jostle the infrared markers on the rug with her hand, or she would play with the markers on the shell. The teacher would respond by putting the markers back, followed by physically and verbally prompting HH to resume the activity. For example, the teacher would try to adjust HH's body to sit up and face her partner, saying, "Can you help me" (4.27)?

After the first few days of the SMALLab 1 sessions, HH became adept at taking her shoes off on her own and immediately dragging her rug onto the floor. She would almost immediately lie down on her rug, with her feet on the ground, knees bent. When the teacher tried to hand her the shell, she sometimes grabbed it and held it against her face. Other times, HH would push the shell away. On occasion, she spoke a single, brief phrase into it but then immediately set it on the ground next to her. Sometimes, she would sit up and shake it or bounce it against the floor.

Because HH would often speak freely or would respond to the teacher's questions even though she was lying down, the teacher often prompted her to use the shell by holding it near HH's face. But HH typically rejected it. Throughout all sessions, HH continued to speak about her favorite snack and foods, e.g., Hot Cheetos (chips), French fries, and spicy or fried chicken.

During HH's third day in SMALLab 1 (Session 6), she showed a spike in communication. Though she was still lying down, she addressed her partner directly using her partner's name, asking how her partner felt: "Are you okay, [partner]?" She verbalized her feelings as well, saying, she "felt sad, real sad" four times, and saying the word "content" three times when the teacher asked how HH thought her partner felt.

SMALLab 2 (HH). HH continued to enter SMALLab, quickly take off her shoes before immediately pulling the rugs onto the floor. After her rug was in place, she would instantaneously pick up the shell, speak into it briefly (e.g., "Spicy chicken" or "What's your favorite snack?") before putting it down to swiftly resume lying on her rug. When the teacher offered the shell to her, she still pushed it away or would take it and then bounce it on the ground to make noise.

The first time that HH noticed the faces on the floor, she noticed her partner's face and started patting the image strongly with her hand (Teacher A, 5.08, p. 3). When HH saw her own face, she also spoke in a higher pitched voice, expressing something that phonetically sounded like, "Joweee!" as she pointed to the picture (p. 8). These expressions suggest that HH was interested in the projected face, though she may not have understood how to manipulate the picture or how it related to the activity. HH continued to alternate between lying down and sitting up throughout sessions, looking at the faces, looking at the SMALLab projection mirror, speaking into the shell from time to time, and occasionally raising to hand the shell to her partner (p. 3).

During Session 14 (5.11), HH sat up more often. The teacher sat behind HH's partner and noticed HH looking around the space more, her eyes wandering and head turning a lot, but with little-to-no focus on her partner's face. The more the teacher hid her face behind HH's partner (which limited eye contact between teacher and HH), the more HH would hand the shell directly to her partner (p. 11). Once the activity finished, HH put on her shoes, but then she walked back to the floor, looked at the face projection, picked up the shell, returned it to the experimenter, and pulled her rug off the floor.

Discussion (HH). Overall, the SMALLab sessions seemed to stimulate HH such that she would take limited direct instruction from Teacher A, regardless of whether the teacher used cards, physical prompts, or verbal prompts. She seemed to enjoy being in SMALLab, however, as she would quickly prepare the space by placing her rug, grab the shell, speak into it, and then sit or lie down on the rug. This could reflect that the agent of authority was transferred from the teacher to the SMALLab environment, even if HH preferred her method of experiencing the environment to teacher instruction. Ultimately, the scenario's design was not sufficient to keep HH engaged in the planned interaction.

Figure 27 plots HH's speech time (solid line) against her turn-taking time (dotted line). In coding the sessions, turns for HH were slightly modified from simply holding the shell, to touching and/or not rejecting the shell, which included letting it sit on her stomach or lap. Across Baseline, SMALLab 1, and SMALLab 2 conditions, it is not clear whether there was an increase or decrease in speech behavior. In Session 6 and Session 12, there are peaks in her speech activity; however, there are also non-turn-based peaks in Sessions 8 and 13, where she speaks more without the shell than with it. For each condition, these may be interpreted as exceptions due to reasons external to SMALLab, such as a high-energy day for HH. It is also equally likely that HH makes no meaningful distinction between speaking with and without the shell—possibly preferring to speak without it rather than speaking with it.

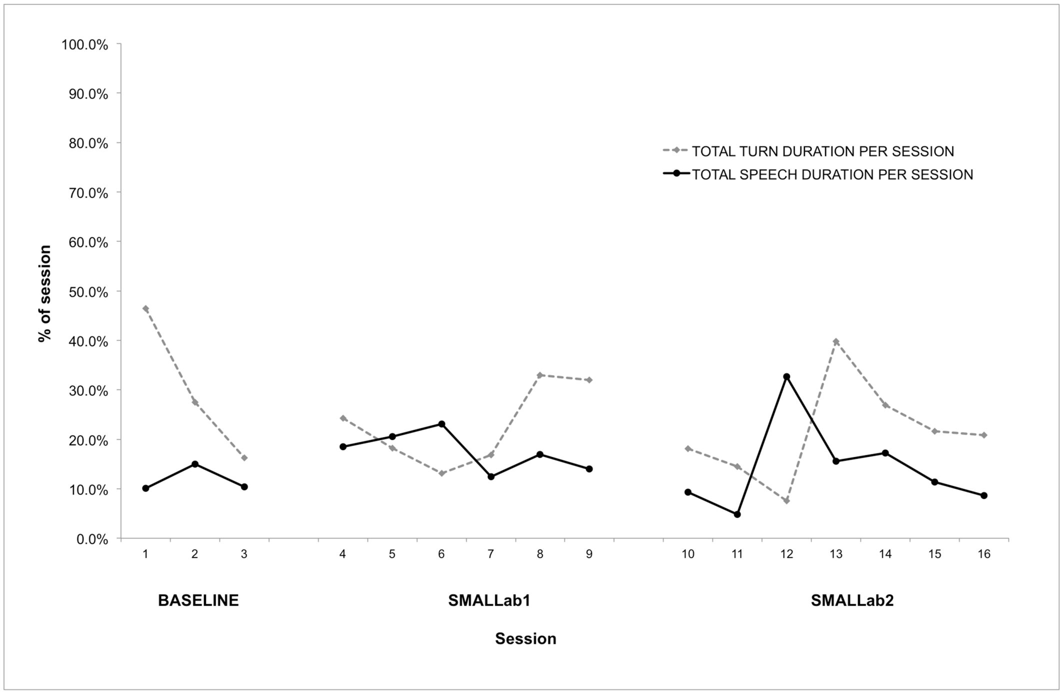

***Figure 27*. HH comparison of percent of elapsed time speaking with turn-taking per session.**

In SMALLab 1, HH speaks anywhere between 10 and 25% of the session time, which is not a significant change from Baseline where she spoke between 10 and 20% of the time. Similarly, she spoke anywhere from 5 to 40% of the time in SMALLab 2; however, there was no stable nor significant change in her speech overall.

Figure 28 looks at turn-based speech (dotted line) versus non-turn-based speech (solid line). There is no clear trend or increased tendency toward speech with or without the shell. One could argue that across the SMALLab 1 and SMALLab 2 conditions that there is a downward trend, in which case, HH speaks more during the earlier sessions of each condition and then becomes less and less interested in speaking. Although she finds interest in participating in SMALLab, SMALLab then becomes an environment whereby she elects to disengage from instruction or participation with others.

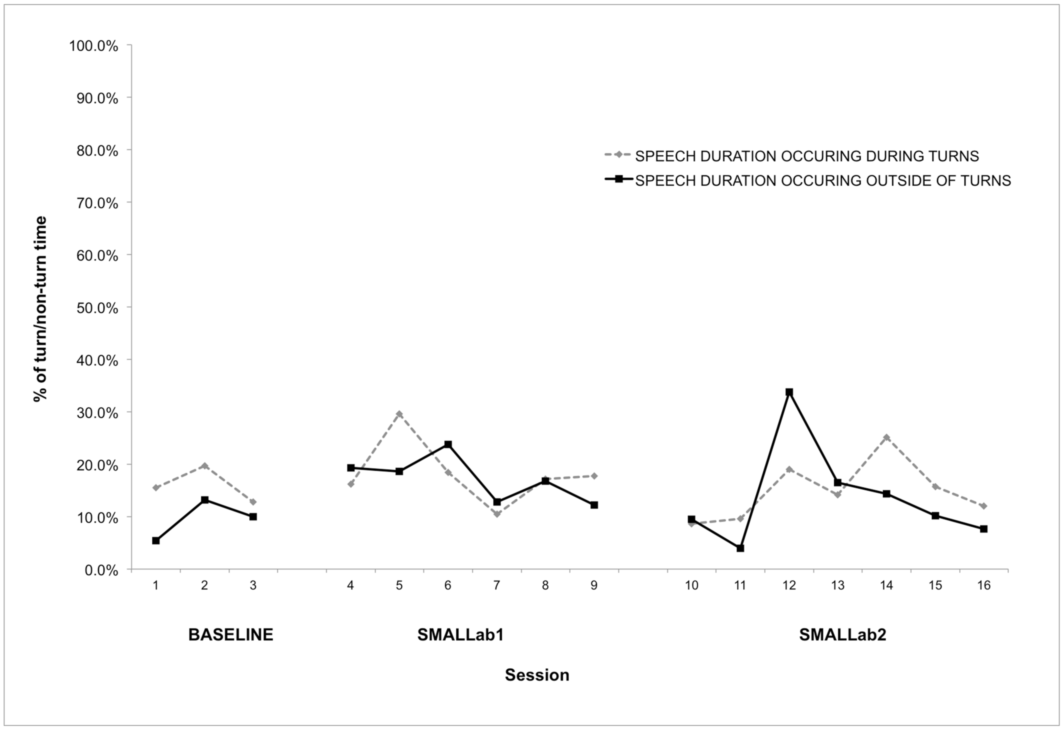

***Figure 28*. HH's comparison of percent of elapsed time speaking during turns.**

Figure 29 plots the median of the central tendencies toward speech during turns and speech between turns. For each condition, the central tendency of speech during turns decreases over time, starting above 20% at Baseline and dropping below 15% by SMALLab 2; meanwhile, speech out-of-turn remains at similar levels across conditions. In fact, during sessions 10 and 11, HH does not speak at all while she has the shell, which is also brief at best.

Figure 29 shows HH's central tendency (median) to speak during turns in each session (dashed line) juxtaposed with her tendency to speak when she does not possess the shell (dotted line). The median plots of each condition suggest that she may have slightly preferred speaking without the shell. This is shown as the medians for turn-based speech fall just above the medians for non-turns. Figure 30 shows the difference between the medians for each condition, suggesting once again that HH was more inclined to use the shell to speak during Baseline than during the SMALLab conditions. In SMALLab, speaking out-of-turn was equally, if not slightly more likely, than speaking with the shell.

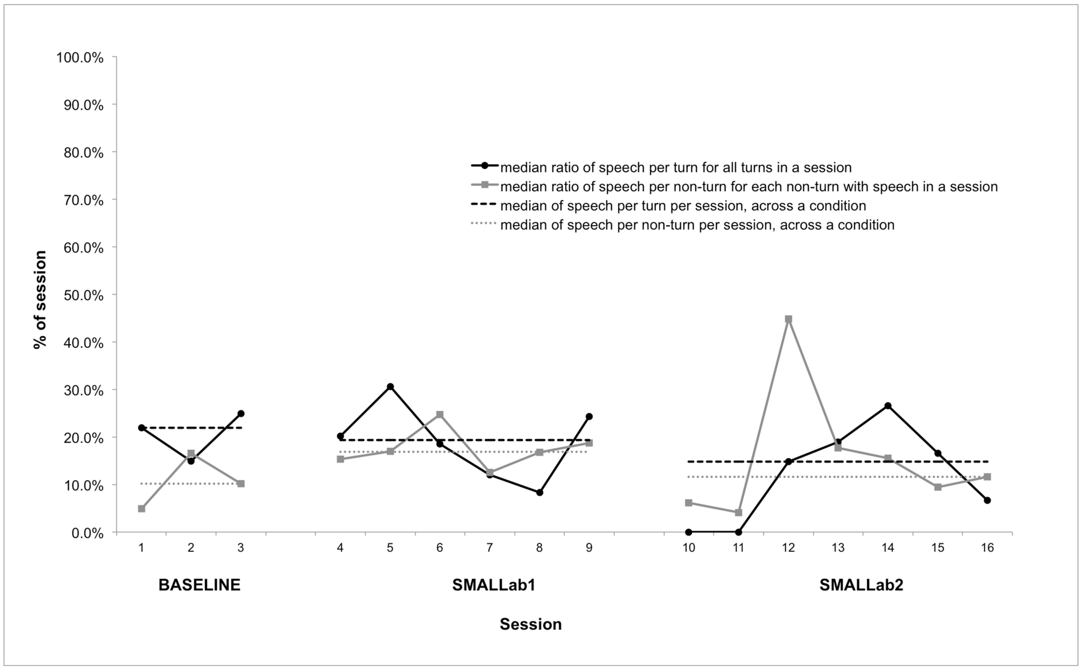

Figure 29. **HH's comparison of median ratios of speech during a turn vs. out-of-turn.**

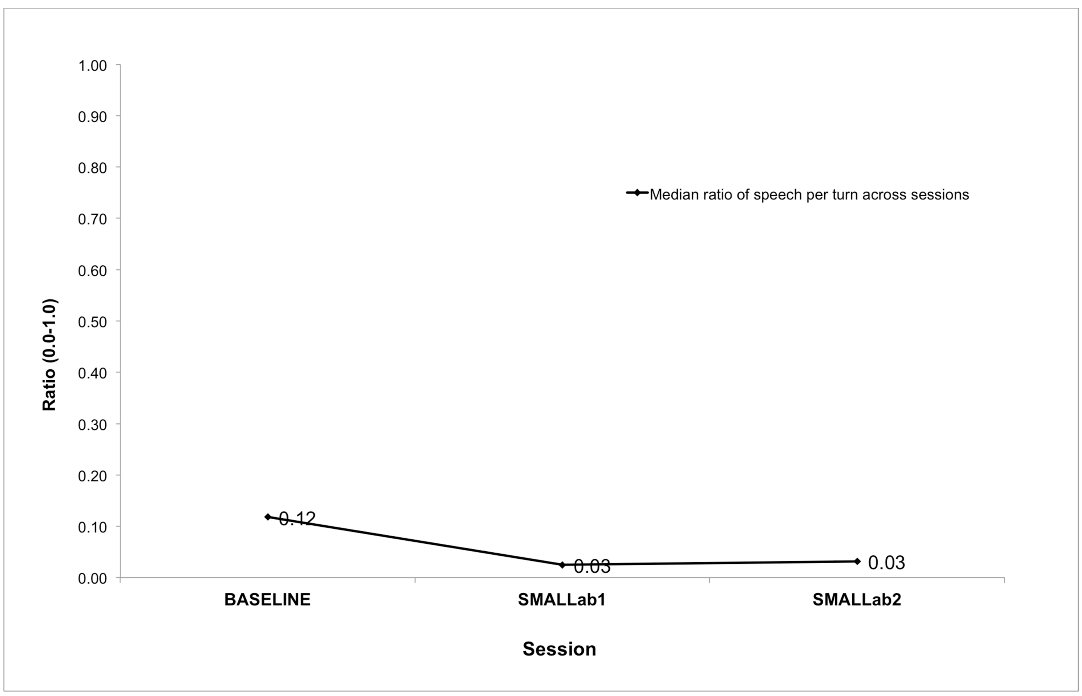

Figure 30. **HH's ratio difference between speaking during turns vs. during non-turns.**

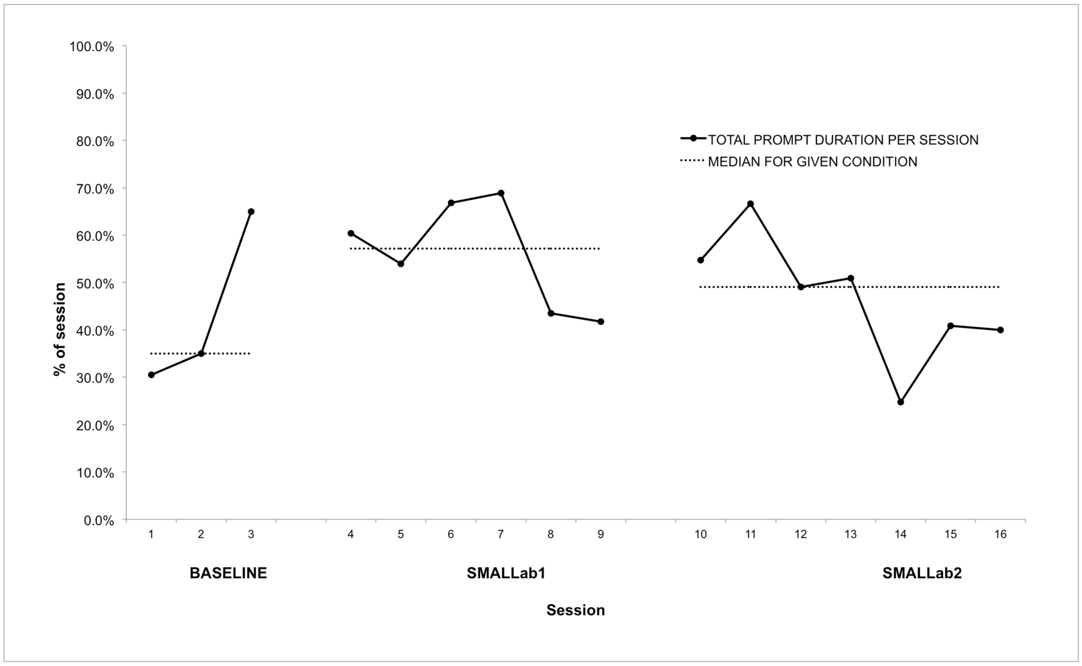

***Figure 31*. HH's percent of each session during which the teacher prompted students.**

Figure 31 shows the percentage of each session that the teacher prompted students. The median for each condition is represented by the dotted line. The median jumps between Baseline and SMALLab 1, followed by a drop in prompts with SMALLab 2. A linear regression line fit along each of the SMALLab 1 and SMALLab 2 conditions would suggest a downward trend in prompts per session over time. HH's speech across SMALLab 1 and SMALLab 2 conditions also follows a downward trend, which may be related to the decrease in prompts/session. Though she may enjoy being in SMALLab, the data suggests that the environment and/or scenario design alone did not sufficiently motivate her to talk or actively participate for an extended amount of time.

To better describe the nature of HH's speech, I transcribed her utterances for each session, first using audio from the video recordings and cross-checking it with the high-fidelity audio captured by the shell's wireless microphone. Of her utterances, I listed, counted, and categorized all utterances that could be made out into plain English words and phrases. One exception was the expression "Jowee," which was distinct and repeated throughout the SMALLab 2 condition. Word or phrase instances per session were counted and placed into a matrix shown in Figure 32, with Categories and Statements (i.e., words, phrases) listed as rows and sessions listed as columns.

During Baseline (Sessions 1–3), HH spoke concretely about food items. She also focused repeatedly on one of the topic cards that referred to “lunch at school,” which she read 12 times during Session 2. During SMALLab 1, the number and variety of words/phrases HH used expanded. In Session 4, she expressed a wider array of food choices. However, in Session 6, her expressions became more abstract, as she repeatedly asked her partner how she felt (“Are you okay, [partner]?” 10 times) and shared her own feelings (“I feel real sad,” 4 times). She also repeatedly mentioned both of her favorite snacks (Hot Cheetos and spicy chicken, 3–6 times) in almost every session, which may indicate something about her sentiment (excited, happy) during the activity. In SMALLab 2, she began saying the phrase “Jowee” in a high-pitched, energetic voice, while she stared at the projection of her face, hovering over it, and tapping it with her hand or foot.

Summary (HH). No solid trends in speech were established for HH as a result of SMALLab. The speech instances in Figure 32 could reveal that SMALLab sessions held unique meanings for HH. Drawing conclusions is premature, but more research may aid to further support her experience.

		BASELINE			SMALLAB 1						SMALLAB 2						
Category	*Statement*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Question	What's your favorite __?		1		2	5	2	3	2	4	3		2	2	1	1	
Question	What happened?															1	
Question	Do you see?														2		
Question	How you feel?						1								1		
Question	Are you okay?						10		3								
Question	Can you hear?						1										
Question	What						1										
Question	Like to food, eat			6													
Question	*read:* (Eat) lunch at school		12														
Person	Hi Grandma														1		
Person	(partner's name)	1					10			1							
Person	(person's name)							1									
Expression	oops														1		
Expression	jowee											3	5	5			
Expression	I'm/feel/real sad						4		3								
Expression	This way						10										
Expression	content						3										
Expression	(no) thank you					2	1										
Expression	so tired						1										
Food	Hot cheetos	2			1	5	2			6	1		2	3	4	2	5
Food	(spicy/fried) chicken		2	1	6	4	4	5	2	3	1			2		4	1
Food	chocolate milk		1		1		1			3					1	1	
Food	potato						1									1	
Food	french fries				1										2		
Food	lunch		2				1							19	1		
Food	sandwich														1		
Food	goldfish crackers								10					1			
Food	ranch									2							
Food	carrot									1							
Food	(sausage) burrito				2	2			1								
Food	Cherry Coke							2									
Food	nacho cheese							1									
Food	Pepsi						2										
Food	celery (quee)					3											
Food	strawberry muffin					1											
Food	milk, white	1		2	1												
Food	salad {ingredient}	1	1	1	1												
Food	chocolate				1												
Food	coffee				1												
Food	Dr. Pepper				1												
Food	hamburger				1												
Food	salmon				1												
Food	shake				1												

***Figure 32*. HH's words and phrases during the sessions, sorted by category. Sessions are numbered left to right, with Baseline, SMALLab 1, and SMALLab 2 conditions separated by the vertical lines. Frequencies of each phrase per session is shown in the matrix.**

EM Trials

Baseline (EM). During Baseline sessions, EM frequently sought the teacher to talk to. Her speech was monotone and fast; phrases lasted less than a second as words ran directly into each other. She would repeat the same phrase 6–8 times, pausing a couple of seconds between each instance. She typically relied on teacher prompts, responding with concrete answers like "99 cent store" or "books and ice cream." When asked to speak to her partner, she would say his name and repeat the topic a few times while awaiting his response. On one occasion she slapped herself, which teachers have acknowledged as a sign of frustration.

EM seemed to understand that she should communicate directly with her partner. However, her partner often tried to ignore her by yawning, looking the other way, or lying down on the floor. As a result, she actively sought a response from the teacher, to the point that the teacher tried hiding her face behind EM's partner to avoid eye contact (Teacher A, 4.25–2, p. 5). EM directly repeated questions or topics the teacher provided, either verbally or with cards, including asking her partner what his favorite snack was (p. 4).

With respect to the shell, EM held the shell when prompted but did not often speak into it. When EM offered it to her partner, he also did not take it without constant teacher assistance (i.e., supporting his hands and body while he held the shell). As a result, EM formally held the shell for most of the time, putting it in her lap or on the floor when her partner did not take it.

SMALLab 1 (EM). Starting a conversation during SMALLab 1 still required the teacher to prompt them. However, EM began requesting topic cards from the teacher (Teacher A 5.08, p. 7), saying, "Card." The teacher found it easier to perform hand-over-hand support to EM's partner, which made it easier for EM to take the shell directly from her partner. EM's partner became more compliant in the activity, making him a more receptive and responsive partner for EM.

EM regularly spoke into the shell. When she was finished, she was quicker to lean forward to pass the shell (Teacher A, 5.08, p. 8). The teacher noticed EM's eyes were more focused on her partner's face, and she did not shift them as much to the teacher. She generated her own material and more patiently waited for her partner to respond (5.11, p. 14–15). As she extended the shell to her partner, her eyes focused on his hand, as she made sure he gripped it firmly before letting go, sitting back, and looking at him.

At times, EM would laugh and put her hands over her face, curling her nose and hands before becoming calm and continuing to smile. The teacher noted this usually happened when EM was elated (p. 8–9). Toward the final sessions of SMALLab 1, the teacher noted that one day after school, EM's mother commented on "how delighted she was that EM was looking right at her mother's face when her mother is talking to her," and that in class, teachers were noticing an "overall … increase of staring at a person's face up close" (Teacher A, 5.11, p. 15–16).

SMALLab 2 (EM). From SMALLab 1 to SMALLab 2, there were no remarkable changes in her behavior. EM focused her speech on her interests (e.g., chores and shopping), repeating questions as before (e.g., "Do you have chores?" 4–6 times with pauses) and providing her own answers (e.g., "I sweep the floor," "I make the bed,") (Teacher A, 5.18, p. 1). The teacher found that if EM spoke while looking down, it was her partner's image that she was looking at, usually while she was starting to speak (5.18, p. 2). EM generated slightly more questions, more detailed phrases, and different content. Her partner was also more compliant, expressing topics that he wanted to talk about, such as the Dollar Store or a badge that he wore (5.18, p. 4–5), but she did not seem to acknowledge what he was saying or reiterate his topic. She just continued to ask and answer her own questions.

Discussion (EM). Overall, EM seemed to respond favorably to the SMALLab conditions. She became more focused on her partner's face without needing to be prompted or redirected by the teacher. She also became more interactive with her partner, finishing her turn with the shell, and then quickly, but patiently offering the shell to her partner.

Figure 33 shows the percentage of each session that EM was either speaking (solid line) or taking a turn (dotted line). The plot suggests that speech and turn durations did not change across conditions. Each of the Baseline and SMALLab 1 conditions, however, show a slight decrease in turn duration for each condition.

Figure 34 shows EM's speech becoming more confined to her turn with the shell, as out-of-turn speech decreased to 0% by Session 11. The jump in out-of-turn speech on SMALLab 2 indicates she did more out-of-turn speaking; however, this increase was due in part to the introduction of the moving face. In SMALLab 2, when her partner's face changed to hers and started traveling away from her, she would look down and say her own name. It appeared that the face change and its proximity to her circle inadvertently cued her to state her name.

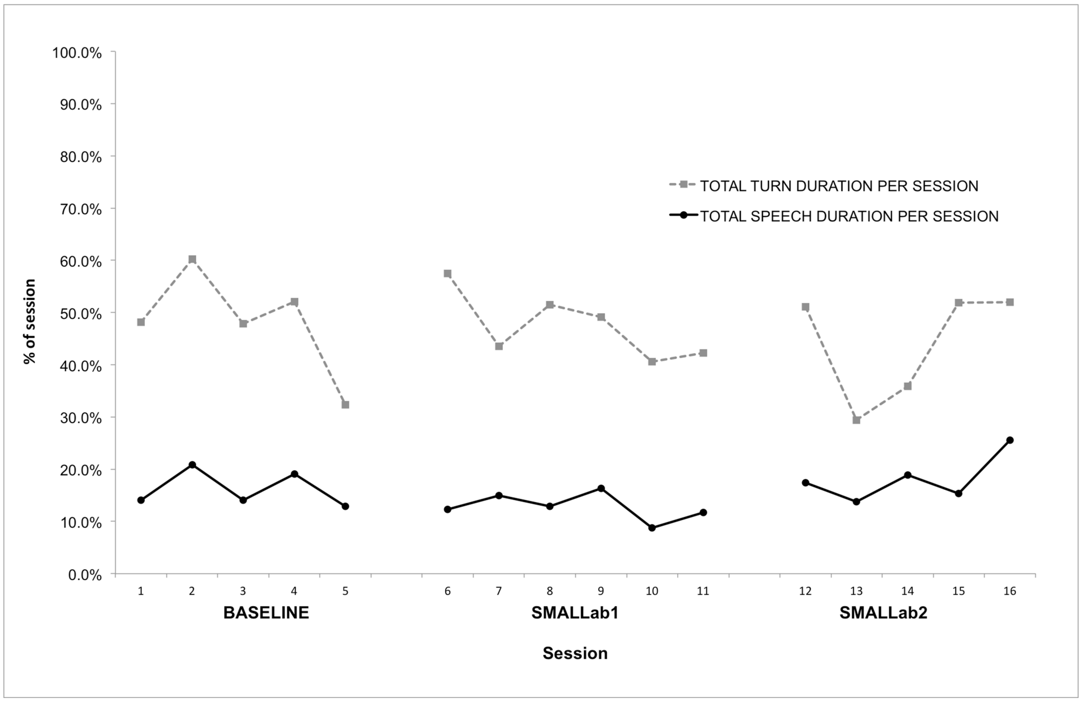

***Figure 33*. EM's comparison of percent of elapsed time speaking vs. turn-taking. Speech per session is shown with a solid line, and turn duration per session is shown with a dotted line. All points represent percentage per session.**

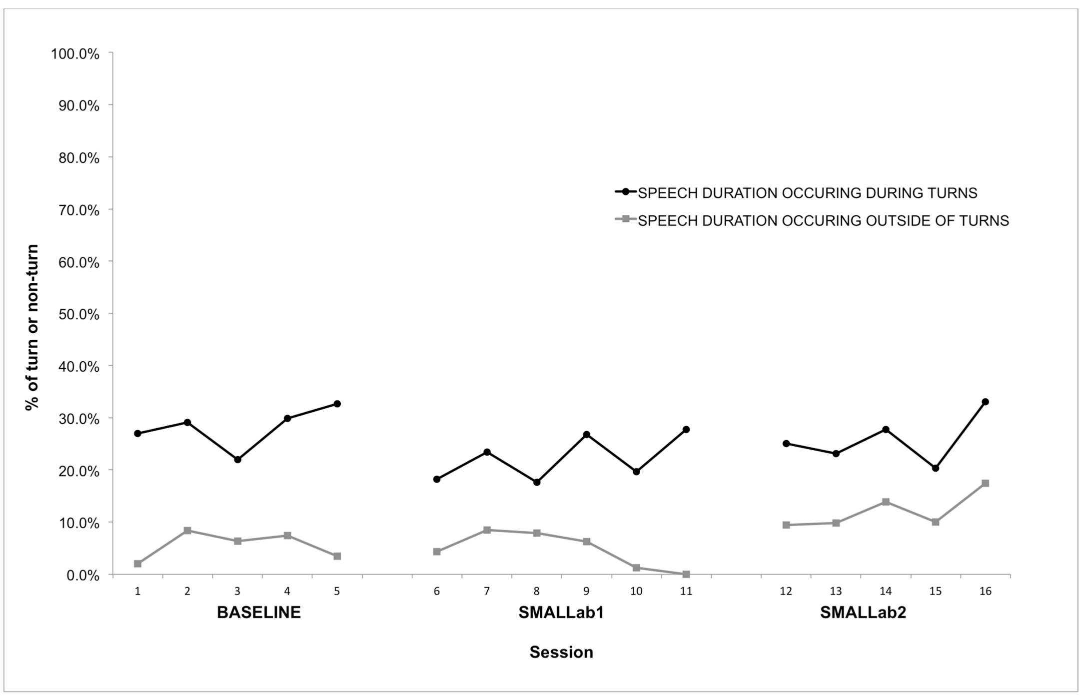

***Figure 34*. EM's comparison of percent of elapsed time speaking during turns.**

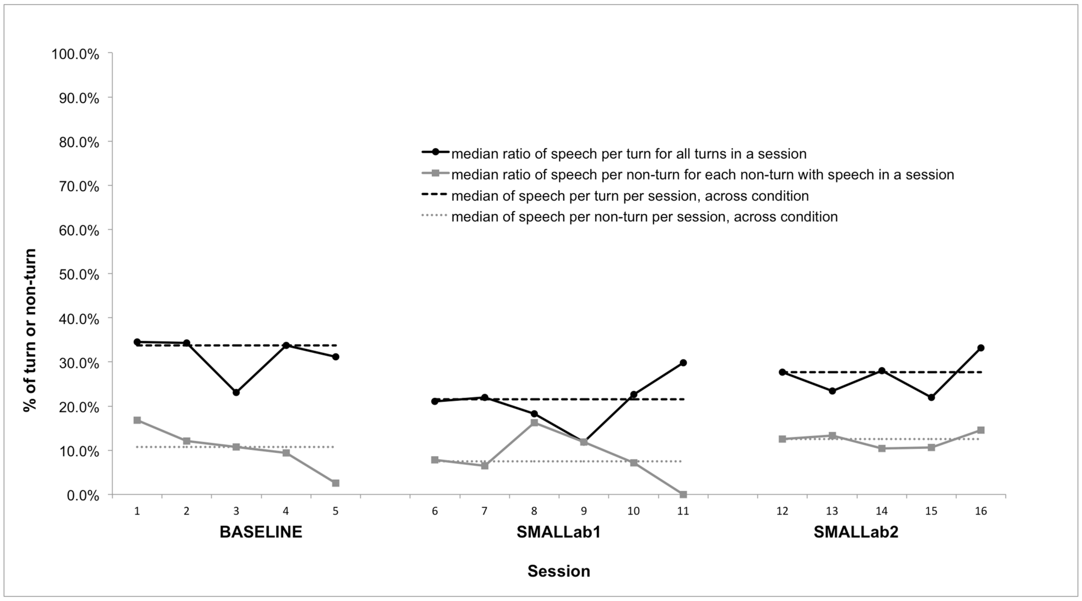

***Figure 35*. EM's comparison of median ratios of speech during a turn vs. out-of-turn.**

Figure 35 illustrates that for speech during turns and speech between turns, little change took place in the median values of each condition. Between Baseline and SMALLab 2, median changes were no greater than 10%. From SMALLab 1 to SMALLab 2, there is an incremental change in the amount of turn-based speech—again, less than 10%. This arguably suggests that EM's progress in the new environment may take more time to develop. Alternatively, it could be that EM's slight increase with language is a result of general practice and maturation.

Figure 36 further clarifies the difference between turn-based-speech and non-turn-based speech per condition. In Baseline, a greater percentage of speech occurred during turns than during the time between turns. However, in SMALLab 1 and 2, that difference diminished, meaning that speech occurred more equally during and between turns. Because EM's speech decreased with the introduction of SMALLab, it could be that the time when she would have persistently directed responses to the teacher or answered her own questions was replaced by a focused patience on her partner.

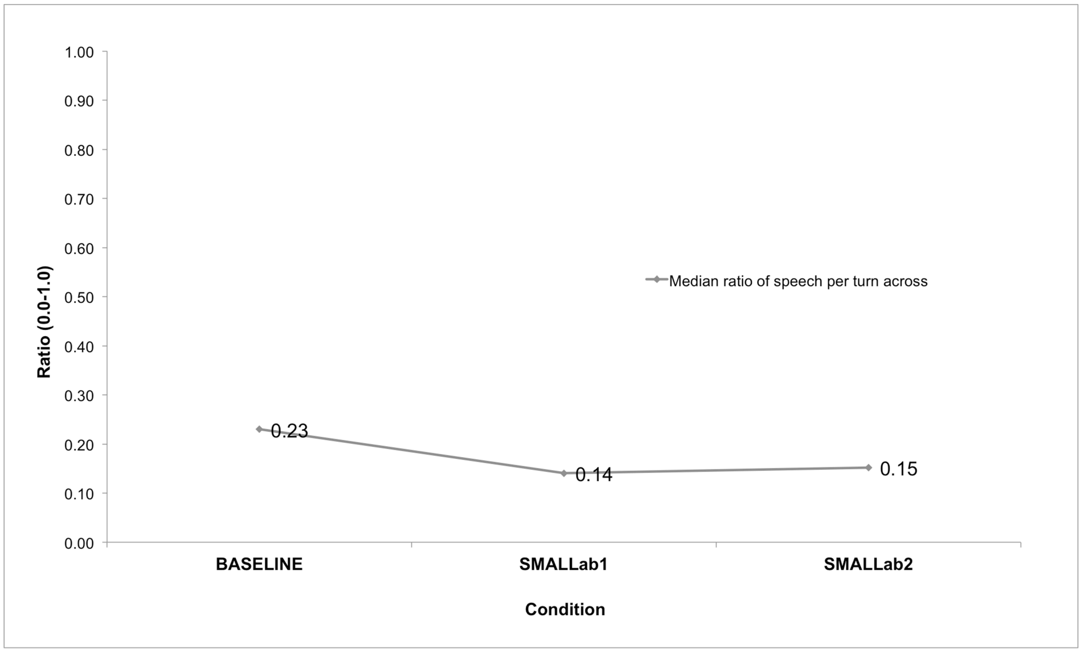

***Figure 36*. EM's difference between median ratios of speech-per-turn. This shows the difference in central tendency between turn-based and non-turn based speech, across the different conditions.**

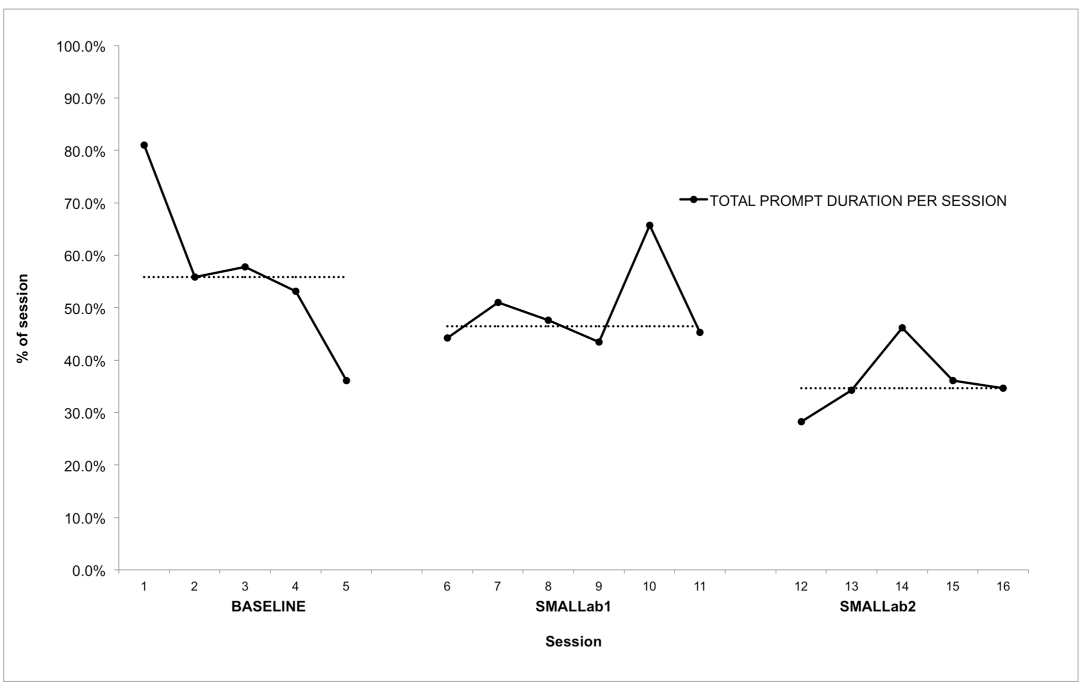

***Figure 37*. EM's percent of each session during which the teacher prompted students.**

Figure 37 shows a clearer trend in teacher prompting. As EM's sessions progressed across conditions, the need for teacher prompts decreased in a stepwise fashion, dropping approximately 10% first from Baseline to SMALLab 1, and then again from SMALLab 1 to SMALLab 2. This finding, when compared with the basic stability in her speech production across sessions, suggests that EM was able to maintain her level of speech with less and less teacher involvement. This could be argued as a natural progression over time; however, the range of prompt/session values in SMALLab 2 drops almost entirely below the range of prompt per session values in SMALLab 1. The addition of faces and the connecting lines may have provided enough additional clarity for interaction that much fewer prompts were required. In fact, during this phase, EM's partner also participated more on his own, requiring less teacher initiation and physical support to pass and receive the shell from EM.

Summary (EM). Overall, between Baseline and SMALLab 1, EM increased in initiating speech on her own, with fewer teacher prompts. She also spoke directly into the shell more than in Baseline. With the introduction of SMALLab 2, she built upon her skill in SMALLab 1 as she increased in her persistence to connect with her partner. She held the shell out and waited longer for him until he took it. Her eye contact with her partner improved, and she said both hers and her partner's name more frequently. The decrease in teacher prompts between Baseline and SMALLab 2 suggest that her internal motivation to speak and initiate conversation increased.

Multiple Baseline Design Summary Graphs

The following graphs include the multiple baseline design across participants summaries for elapsed time per session speaking and turn-taking (Figure 38), teacher prompt duration per session (Figure 39), and median ratios and speech per turn in a session for a given condition (Figure 40).

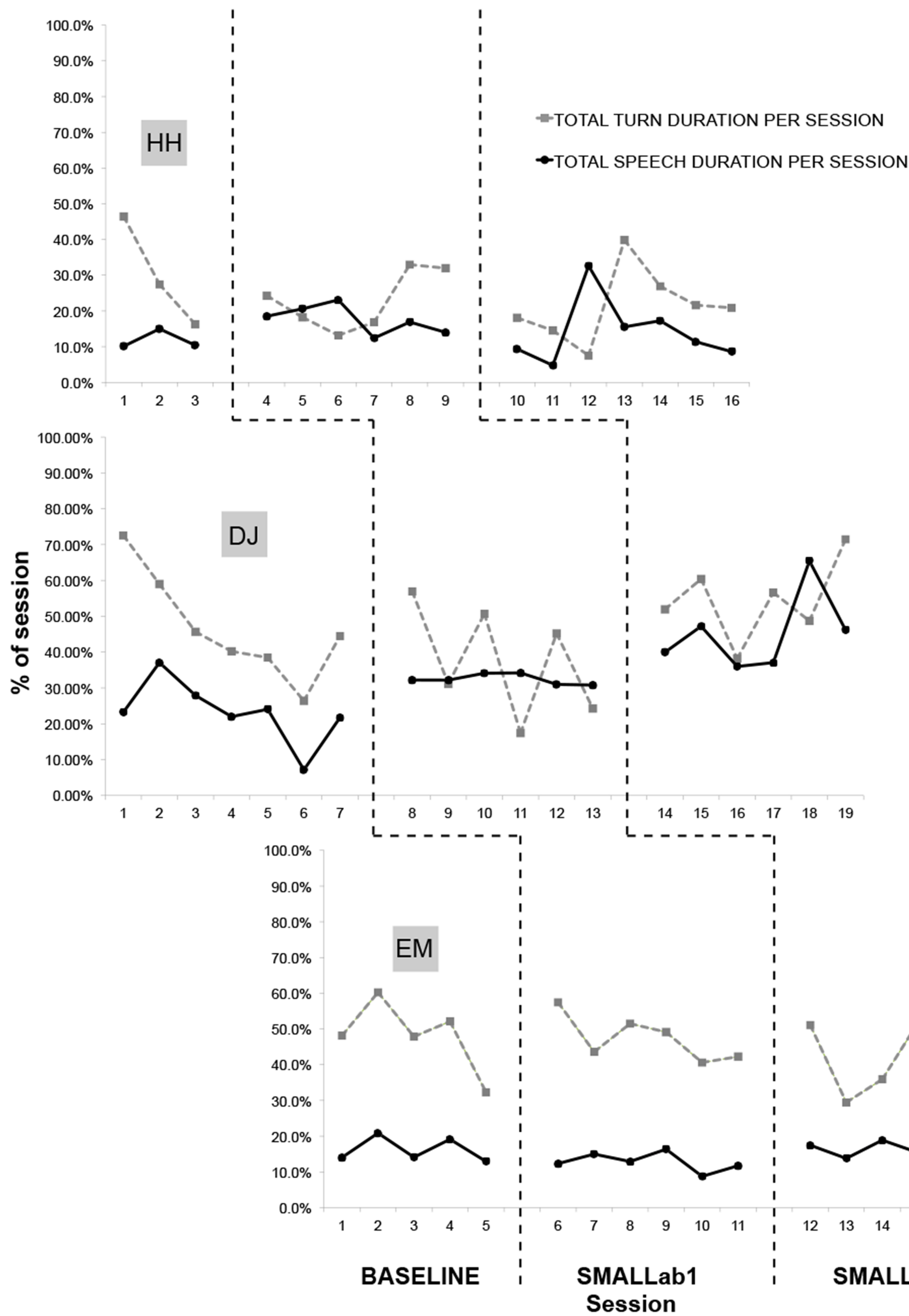

***Figure 38*. Summary of elapsed time speaking versus turn-taking. Note: Baseline for EM is offset due to sessions a later session start date.**

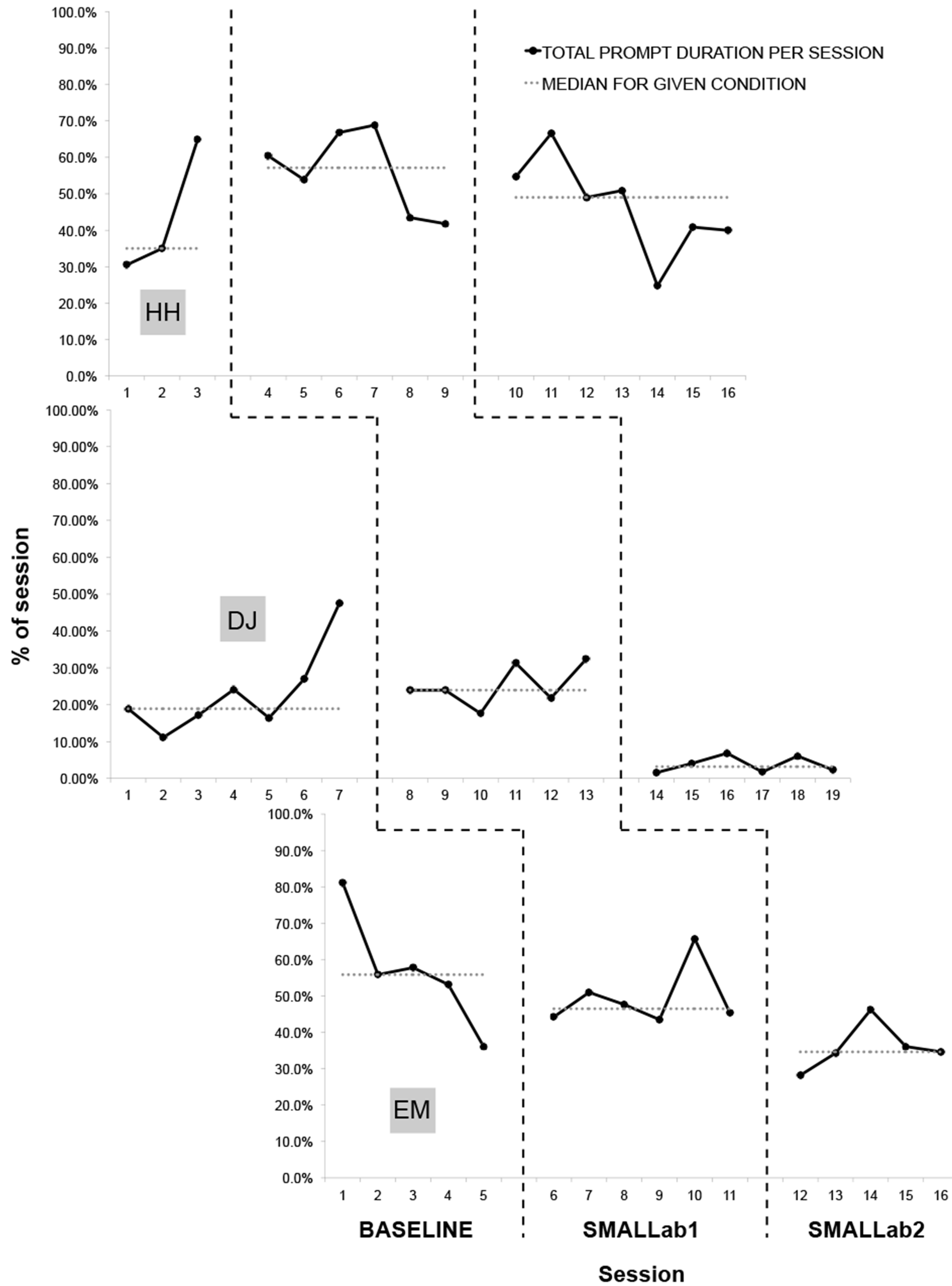

***Figure 39*. Summary of percent of sessions comprised of teacher prompts. Note: Baseline for EM is offset due to sessions a later session start date.**

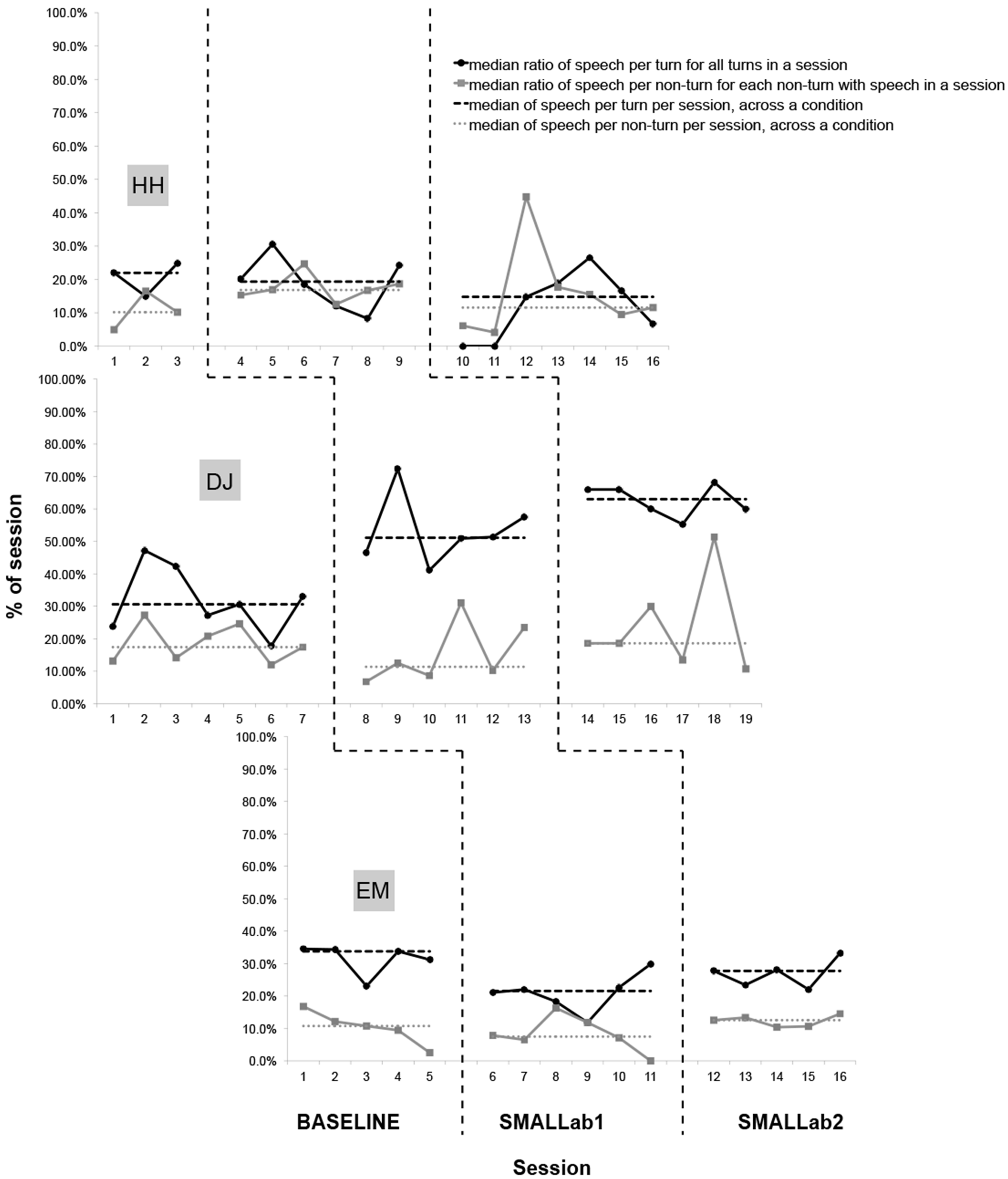

***Figure 40*. Summary of median ratios of speech per turn for all turns in a given condition. Note: Baseline for EM is offset due to sessions a later session start date.**

Post-experiment Observations

The last post-session interview and both post-experiment interviews by teachers provided insights into the students' interactions in the regular classroom. Teacher B speaks about these changes that she noticed entirely outside of SMALLab, because she had never accompanied nor visited students in SMALLab during the experimental phase. Teacher A discusses changes she had seen, commenting on her own teaching style, and making suggestions for improving the SMALLab scenario.

Observing DJ in class. Teacher B believes DJ really enjoyed SMALLab "because he got to hear his voice" and "he just seemed proud of himself." After having come back from SMALLab, he would tell Teacher B, "Oh, I did. I went to SMALLab," answering, "Yes," when asked if he had fun, and clearly stating what he did, e.g., "I talked into the shell" (Teacher B, Post-experiment interview, p. 6). The following excerpt continues from Teacher B's post-experiment interview (p. 6).

> He's just streaming together sentences that sound not [like a] TV voice, but genuine. … It sounded so normal and so typical. He's usually like, "Well, hello," and he goes to his announcer voice…. Even when he's had some more conflict:
>
> "Can we talk?"
>
> "Yes." He pulls his headphones out.
>
> "Well, your mom said this. Is that true?"
>
> "Yeah. I fed the ducks."
>
> "What did you feed the ducks?" '
>
> "I fed them bread."
>
> "Okay."
>
> "I'm pulling stuff from home and he's answering and it's not in his cartoon voices or announcer voice; it's in his voice. I think it helped him find his voice. I don't know. I think he really loved it, hearing his voice." "I think hearing his voice helps him put his thoughts together sometimes."

This contrasts with Teacher B's observation of him prior to the experiment, where she had to ask him questions prefaced with "I …" so that he could echo her while filling in the blank.

Teacher A mentioned that DJ had been talking so much with his SMALLab partner in class that at times, they have to separate them so they can focus on individual work. However, the nature of pre-existing class structure does not allow for DJ to express himself for as long, or as deeply, as the SMALLab activity has. Teacher A stated that she has heard many of his talks in brief in class, but she remarks:

> Being in this setting, I can really listen to his mind more when he talks out loud, because I hear him…. Even though I can't really tease things out so accurately, I feel like it helps

> open up a little bit more about how he thinks, and what he might truly be trying to convey despite what comes out of his mouth. This SMALLab setting of letting them have time to unfold what's inside of them can help us really study how their thoughts are flowing through their minds and without a lot of triggers. It's dark. There's a plain floor. It's not like there's a lot of visual distractions. It helps me tune into how quickly his thoughts are shifting. … Maybe some of that eBay talk is really communicating towards the other person of just having something to say the real practical phrase that is precise is not yet coming out. You're saying something that's the first thing you can think of. Maybe it has a different meaning than what we hear. (Teacher A, 5.11, p. 18)

The teacher was finding that his fantasy talk may have been more of a primer to loosen himself up to say more, such as using the word "together" three times in succession in one thought.

Observing HH in class. Overall, HH was talking more. During the beginning of the SMALLab 2 sessions, Teacher A commented that the class received a call from HH's home stating their appreciation to the classroom, saying "HH's really communicating with us at home. Her words are clearer now" (Teacher A, 5.08, p. 4). Teacher B confirmed this, noting that "even her group home called and asked what we were doing at school 'cuz they noticed how much more verbal she's been; instead of just making noises and noises that she hears on TV" (Teacher B, Post-experiment interview, p. 1–2). This marks an improvement from Teacher B's pre-experiment description of HH, where she was more often engaged in echolalic talk or made loud noises to communicate or gain a teacher's attention. HH was also speaking to peers at lunch (Teacher A, 5.08, p.4).

Observing EM in class. Teacher B remarked that, "A light bulb, a huge light bulb, has turned on for EM it seems this last semester, but more so in the past few weeks. She's really, really seeking out people to talk to." Before, she used to make lists and draw pictures and hand them to you. "Now she's seeking people out to have conversations with them as a preferred activity because she wants to talk about her preferred activities with somebody.… She's become a more persistent communicator. Her proximity is such that she's getting closer to people to come talk to them" (Teacher B, Post-experiment interview, p. 4).

EM also joined Koosh Ball Talk (which is a group conversation activity using a soft ball) the Monday after her last SMALLab session. This was a major event for her according to Teacher B, because "she's never done that before. [Now] She wants to be around people. She's sitting there. She's paying attention. She was listening. I don't know – she doesn't normally do that" (Teacher B, Post-experiment interview, p. 5).

Teacher A stated that of all the kids, EM most notably improved. She now seeks out others to talk to:

> I have seen EM become better at looking at someone's face and waiting for her turn to speak. When I ask her what the other person's answer is, she has been answering correctly like four out of five times. So it was nice to see *EM want to join in a conversation at the leisure table*, and there were two friends for her to choose to talk to. She remembered each of their names, and chose on her own which friend she wanted to address the question to. I didn't have to force her like, 'Oh, take this turn. Then take that turn.' *She had her own idea of who to ask*. … When she was done with the question, she remembered to pass the card to them so they could flip it over and have the prompt for how to answer the question. So *she patiently waited* while they had their turn to tell her. Then I saw her making eye contact with them, depending on who was speaking to her. (Teacher A, Post-experiment interview, p.7–8)

This is in contrast to the description of EM during the pre-experiment interview, where Teacher B stated that EM did not typically engage with her peers; just her teachers. Also, the description indicates that EM practices taking turns and waiting patiently until another student completes his or her statement, which again, contrasts with her baseline behavior, where she would simply answer any question that the teacher asked, regardless of whether the question was being asked of her.

Overall observations. Teacher B expressed that all students participating in SMALLab were paying more attention to one another. For example, DJ, EM, and HH, would each grab his or her partner's hand to go to SMALLab together as a pair. The students now waited for their partner to go rather than starting off alone, which was not something that happened consistently in the early part of the year. Different students have also been interacting with one another, and all students have been using more language (Teacher B, Post-experiment interview, p. 1–2).

Another observation is that the results seem to suggest that DJ, who is male, had exhibited greater amounts of speech in SMALLab, whereas HH and EM, seemed to decrease or plateau in speech, even if their independence and partner focus fluctuated or increased. Future work could include a study of gender bias with respect to the interaction design of a SMALLab scenario.

Effect of the Environment and Experiment on Teacher A

Teacher A, who served as the primary facilitator throughout the SMALLab experiment, was profoundly changed by the experience. During the experiment, Teacher A was conscious of was the degree to which she was allowing students to have greater agency.

> I was letting them be independent as much as they could possibly be, [and to a small degree] allowing them to be a little bit more independent in the SMALLab experiment … compared to sometimes over-prompting them in the classroom. That is such a fine line. There were moments where I felt like I was holding myself back from urges to prompt. It worked to my advantage, or to DJ and his partner's, when I held myself back they actually started speaking on their own. (Teacher A, Post-experiment Interview, p. 3)

Teacher A described the regular classroom as having lots of environmental prompts, visual instructions, and procedural lists that students were expected to follow. In contrast, with SMALLab, Teacher A found that "there was more of a playful, relaxed feeling that I felt like I was being more positive with them. I wasn't there to remind them about the things they were doing wrong so much as I wanted to back off and let them find their own way even more in SMALLab" (Teacher A, Post-experiment interview, p. 3). Teacher A's choice to refrain from over-prompting grew over time as she entrusted students to take greater control of the interaction and express themselves freely without relying upon her prompts. This may have contributed to their sense of presence, because their behavior was not being constantly corrected nor prescribed. In this way, Teacher A's authority receded as the media feedback prepared students for the next step.

As outlined in Chapter 4, the scenario was designed to positively reinforce behaviors by amplifying and extending vocal utterances through audio-visual projection effects. Teacher A describes the experiment's affect on her own prompting methods. She reveals that she felt compelled to use positive reinforcement of favored behaviors, which pedagogically remains consistent with the scenario's aesthetic to amplify.

> The SMALLab experiment helped me to practice a more positive way of redirecting the student. I focused on reminders of how to hold the shell rather than say, 'Don't tap. Don't burp.' The big realization [was] that because this is research, I wanted to ensure that they would have a good attitude about revisiting, because I knew that the research was dependent on their attendance…. I didn't want to risk them having a negative association with going to SMALLab…. To me, the point of them being in SMALLab was for them to kind of feel free to really discover that inner voice without worrying about, 'Am I doing it right? Am I speaking the right way? Am I speaking loud enough? … I wanted them to have more self-discovery in hopes that they could just discover more about themselves. (Teacher A, Post-experiment interview, p. 4-5)

Teacher A also became acutely aware of the impact of her person and presence in the SMALLab activity. In a reflection regarding baseline sessions with EM, she expressed that as she was verbally prompting students, she began to feel as though “my body was getting in the way,” which lead her to create written prompts. However, during SMALLab 1, as she continued re-entering the space to exchange old cards for new ones, she realized that the students were still relying on the cards (Teacher A, 5.1, p. 16). The salient point here is that the physical presence of these supports, i.e., the teacher and the cards, was to some extent, introducing a dependency that was not easily removed or ignored. However, even though the SMALLab projection provided a virtual support, it may have also been somatically or visually retained by students, which may have contributed to their continued interest in peer interaction in the classroom.

To summarize, the teacher’s awareness of the aesthetic design – its openness, its emphasis on presence and agency, and its positive reinforcement via media – impacted and changed the nature with which she worked with her students over time. Future work could investigate exactly how immersive media learning experiences such as this one changes a teacher, his or her perceptions and pedagogy, as well as the greater culture of learning in the teacher’s homeroom. For example, are there specific elements or unexpected events that occur in SMALLab that lead to improved communication strategies, physical homeroom organization, lesson plans, or more customized support for each and every student?

CHAPTER 6

Conclusion

Results from this study suggest that the activity was successful in increasing independently generated speech in some students, while increasing a focus on seeking out social partners in others. Furthermore, the activity presented a number of future directions in research on the nature of voice and discourse, rooted in the use of aesthetics and phenomenology, to augment, extend, and encourage developments in directed communication skills for youth with autism.

Overall, the data showed that the environment supported consistent expression and exchange for some pairs while causing dissipation for others. In each pair, one student was stronger than the other, and where the tool was successful, the stronger student worked harder at trying to engage his/her partner. As the media progressed from A to B, the teacher's presence was needed on a case-by-case basis: The best pair required almost no prompts to engage in continuous exchange, versus the weakest pair requiring prompting from the teacher almost the entire time. The environment enabled students to experience theirs and their partners' voices in an embodied way that is simply not possible in a traditional, unmodified classroom.

Conversational topics were seeded in the initial baseline phases as part of the teacher's standard approach – experimenting until she finds something that works to keep students engaged. What got preserved when the teacher stepped back was what was most recent and relevant to the students' day, mainly, the topic of food or emotions. In the post-session interviews, the teacher expressed that over time, she felt that her person and her presence were getting in the way of students. This statement expressed her dramatic shift in perspective, from feeling that she needed to be present to help the students, and realizing how technology could support them to a point where she was able to step back and intervene only when absolutely necessary (that is, when expression or exchange was taking place for a considerable amount of time).

The change in her perception of her role, as well as her perception of what the students were capable of, allowed her to see what the potential of pedagogy was for the classroom as well as the potential for future modifications to a similar media technology environment. Ultimately, she saw the benefit of the environment as enabling student autonomy, thus leaving her with the flexibility to observe and assess students' current level of expression and vocabulary. Being able to observe the students with some distance gave her insight into their personal expression and interpersonal skill level that she could not have seen if she had to constantly be in the middle of the conversation, monitoring and prompting with great frequency.

Technological Improvements to the Scenario and Pedagogy

Teacher A felt the following aspects of the SMALLab scenario were successful:

- The individual colored circles.
- The colors brightening up around the person and sparkling effect as a person's voice became louder. They thought, "the colors brightening up around the person was interesting to certain students [such as] DJ"; "it really made them notice and test the equipment out" (p. 1).
- That the stream generated thicker lines the longer and more continuous talking occurred.
- The floating faces moving on the same path. "I saw, more than a few, instances where the student would look down at the face. As the face moved, it would lead the student's eyes up to the eyes of the student on the receiving end that they are talking to. Also, I felt like the faces helped the students direct a concept to the other person because what I realized in the end pairs such as DJ's and EM's showed that they were responding or speaking to the faces on the floor. For even a brief moment, they were glancing at the faces." (p. 1)

Teacher A felt that the following could be improved:

- For EM, the appearance of EM's face at the end of her turn may have accidentally cued her to talk, thinking that it was her turn. (p. 5) An improvement might be placing or revealing the face closer to EM's partner's circle, i.e., use proximity of the face to indicate that it is her partner's turn to talk rather than hers.

- Using individual microphones that can be switched on and off between turns might improve the difficulty of sharing the microphone while sitting at a distance from his/her partner.
- Spotlight on each person is better defined to further clarify whose turn it is to speak. (p. 6)

In addition, the teacher wanted to modify the scenario with:

- Word or question prompts that rise, pause, and fade
- A push button on the shell or floor to trigger or change a prompt. (p. 6–7)

The utility of the shell had mixed results. For HH, the shell's texture, weight, and moveable parts (i.e., velcro reflective markers) were distractions. Sometimes she would feel its edges or shake it to make sound, rather than speak into it. Other times, she would hold the shell close to her face and eyes and did not want to relinquish it (Teacher A, 5.08, p. 4). DJ and EM, however, used it as expected for the SMALLab activity.

Embedding the Teacher in Immersive Media Experiences

During a SMALLab 1 session with EM, as the teacher was giving the students verbal prompts, she began to feel like "my body was getting in the way," which led to her creation of written prompts. However, as she started to be the one to enter back into the space and help them with exchanging the cards, she realized they, too, were becoming reliant on the cards (Teacher A, 5.1, p. 16). Here, the teacher articulates a common fear amongst teachers – that one day, some tool will replace a teacher. The tool in this case was not designed to give teachers the kind of presence that was meant for the students, but the choice was indeed, intentional. The goal of teaching students to communicate has to be such that the scaffolds are truly able to recede into the background, so that mastery can take the place of dependency. A future experiment might be to explore the nature of seamlessly embedding teachers into an immersive media experience.

Expanding the Socio-cultural Contexts of Media Environments

There are clear limitations with respect to the results of this experiment, including the length of the study, the number of subjects, the degree to which participants were matched in their level of communication or diagnosis, gender bias, and the a more in-depth approach to variances on what embodiment looks like with respect to voice and embodied design. However, the results are promising in the sense that this kind of environment is motivating for youth with autism to participate in, to the extent that they are willing to learn socio-communication skills that are otherwise viewed as difficult to learn, or to teach, in the traditional classroom. However, a core limitation on the activity is that students are not paired with an expert speaker, which is a symptom of special education in general. As a result, a large piece of the sociocultural impact on self-expression, identity, and voice is missing. One approach to future studies might be to construct the activity such that more typically developing peers also participate, in order to see if the environment can benefit from a more inclusive and culturally aware model of education.

Due to the nature of the public school system and segregated special education programs, this study still points to new opportunities to build more customized approaches to teaching – specifically, approaches that are leveraging hidden or typically unnoticed strengths that may be somehow linked to their perceived impairments.

A phenomenological or avant-garde approach to education can offer multiple ways of framing learning design that allows education to adapt, and be adapted by, people with different modes of being. Both *Sea of Signs* as a specific experience and a variety of scenarios for SMALLab and SMALLab-like environments have allowed for different learners to encounter learning in new ways that may have been powerful enough to have allowed learning transfer to take place.

There is still more to investigate, particularly with respect to the content on the fringe, i.e., the unexpected words and behaviors that emerged as potential openings into designing more targeted or customized learning experiences. Rather than trying to design for a blanket impact on all students, perhaps the next step is to design an adaptive experience or an environment that allows for highly nuanced learning. It is in that way that we can construct learning opportunities that truly allow the unique identities of students to be revealed, to be heard, and to be discovered.

Ultimately, it is my belief that students who are profoundly impacted by disabilities, and who have been removed from the social and cultural playing field, will benefit most from being returned to field. But the actors in our “normal” fields must also change their habitus. If it can work for students with autism, it is certainly possible that a phenomenological approach to education can instigate a true transformation of society that begins with our young citizens. As we release the medical lens through which we judge our bodies, and seek beyond social and economic perspectives for where equity lies, we may find that we all have what we need within us, and it is more a matter of activating our inner potential, rather than looking externally, to move forward.

This study serves as a point of departure for exploration into embodied and mediated environments for special education. The results suggest that immersive media environments like SMALLab can offer promising, unique, and powerfully customized learning experiences that can reshape how we think about, and teach to, our youth with autism.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

ASU Knowledge Enterprise Development

Office of Research Integrity and Assurance

To:	Elizabeth Kozleski SST
for **From:**	Mark Roosa, Chair Soc Beh IRB
Date:	10/10/2011
Committee Action:	**Expedited Approval**
Approval Date:	10/10/2011
Review Type:	Expedited F7
IRB Protocol #:	1110006946
Study Title:	Sea of Signs - Augmented Reality Learning in Special Education
Expiration Date:	10/09/2012

The above-referenced protocol was approved following expedited review by the Institutional Review Board.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date. You may not continue any research activity beyond the expiration date without approval by the Institutional Review Board.

Adverse Reactions: If any untoward incidents or severe reactions should develop as a result of this study, you are required to notify the Soc Beh IRB immediately. If necessary a member of the IRB will be assigned to look into the matter. If the problem is serious, approval may be withdrawn pending IRB review.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, or the investigators, please communicate your requested changes to the Soc Beh IRB. The new procedure is not to be initiated until the IRB approval has been given.

Please retain a copy of this letter with your approved protocol.

ASU Knowledge Enterprise Development

Office of Research Integrity and Assurance

To:	Colleen Megowan Learning S
From:	Mark Roosa, Chair Soc Beh IRB
Date:	10/10/2012
Committee Action:	**Renewal**
Renewal Date:	10/10/2012
Review Type:	Expedited F7
IRB Protocol #:	1110006946
Study Title:	Sea of Signs - Augmented Reality Learning in Special Education
Expiration Date:	10/09/2013

The above-referenced protocol was given renewed approval following Expedited Review by the Institutional Review Board.

It is the Principal Investigator's responsibility to obtain review and continued approval of ongoing research before the expiration noted above. Please allow sufficient time for reapproval. Research activity of any sort may not continue beyond the expiration date without committee approval. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol on the expiration date. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study termination.

This approval by the Soc Beh IRB does not replace or supersede any departmental or oversight committee review that may be required by institutional policy.

Adverse Reactions: If any untoward incidents or severe reactions should develop as a result of this study, you are required to notify the Soc Beh IRB immediately. If necessary a member of the IRB will be assigned to look into the matter. If the problem is serious, approval may be withdrawn pending IRB review.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, or the investigators, please communicate your requested changes to the Soc Beh IRB. The new procedure is not to be initiated until the IRB approval has been given.

Please retain a copy of this letter with your approved protocol.

ASU Knowledge Enterprise Development

Office of Research Integrity and Assurance

To:	Colleen Megowan Learning S
From:	for Mark Roosa, Chair [signature] Soc Beh IRB
Date:	01/17/2013
Committee Action:	**Amendment to Approved Protocol**
Approval Date:	01/17/2013
Review Type:	Expedited F12
IRB Protocol #:	1110006946
Study Title:	Sea of Signs - Augmented Reality Learning in Special Education
Expiration Date:	10/09/2013

The amendment to the above-referenced protocol has been APPROVED following Expedited Review by the Institutional Review Board. This approval does not replace any departmental or other approvals that may be required. It is the Principal Investigator's responsibility to obtain review and continued approval of ongoing research before the expiration noted above. Please allow sufficient time for reapproval. Research activity of any sort may not continue beyond the expiration date without committee approval. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol on the expiration date. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study termination.

This approval by the Soc Beh IRB does not replace or supersede any departmental or oversight committee review that may be required by institutional policy.

Adverse Reactions: If any untoward incidents or severe reactions should develop as a result of this study, you are required to notify the Soc Beh IRB immediately. If necessary a member of the IRB will be assigned to look into the matter. If the problem is serious, approval may be withdrawn pending IRB review.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, or the investigators, please communicate your requested changes to the Soc Beh IRB. The new procedure is not to be initiated until the IRB approval has been given.

Please retain a copy of this letter with your approved protocol.

APPENDIX B

TEACHER CONSENT FORMS

SEA OF SIGNS – AUGMENTED REALITY LEARNING IN SPECIAL EDUCATION

INFORMED CONSENT FORM
ARIZONA STATE UNIVERSITY

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TEACHER/STAFF CONSENT FORM
SEA OF SIGNS – AUGMENTED REALITY LEARNING IN SPECIAL EDUCATION

INTRODUCTION
The purposes of this form are to provide you (as a prospective research study participant) information that may affect your decision as to whether or not to participate in this research and to record the consent of those who agree to be involved in the study.

RESEARCHERS
Elizabeth Kozleski, Professor, School of Social Transformation, and Lisa Tolentino, Doctoral Student, School of Arts, Media and Engineering (AME), at Arizona State University, have invited your participation in a research study.

STUDY PURPOSE
The purpose of the research is to better-understand to what extent an augmented reality environment can improve social engagement experiences for youth in special education. Specifically, we are exploring how different dynamic visual displays (i.e., images, slow-moving graphics) that are triggered by the voice can support verbal communication.

DESCRIPTION OF RESEARCH STUDY
If you decide to participate, then you will join a study involving research of an augmented reality experience that uses the voice to trigger different kinds of audio-visual media (slow-moving images, graphics, sounds). Pairs of students will be invited to communicate verbally with each other in this experience, which will take place in the Situated Multimedia Arts Learning Lab (SMALLab) on your campus.

As a teacher, you may be asked to participate in one of three ways: (1) to help facilitate the interaction between students in the SMALLab, (2) to be part of a focus group interview on participating students' styles and preferences for learning and communicating (approx. 60-90 minutes), and/or (3) to be part of short follow-up de-briefings or focus-group interviews after each of the SMALLab sessions (lasting between 10-20 minutes each).

SMALLab sessions will last for the course of one (1) class period during a regular school day. Sessions will run 2-3 times throughout the week, for approximately 10 weeks during the regular school year. During each session, a randomly selected pair of students will enter SMALLab and interact with each other for 15 minutes at time. Once they have completed the time, a new pair of students will enter for their 15-minute trial period. We anticipate 3-4 pairs per SMALLab session. During this time, your role as a teacher/staff may be to help students during the experiment or help transfer students back and forth between the regular classroom and SMALLab. SMALLab sessions will be videotaped and only used by researchers for coding and analysis.

Interviews will be videotaped (or audio-taped if you prefer) and will only be coded and used for analysis of results. All names and identifiers will be separated from transcripts. During interviews, you may request to skip questions. Additionally, you may ask the interviewer to turn off the recording at any time. You may also request a transcript from the interviewer if you would like to review or revise what you have said.

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If you say YES to this study, then your participation will last for approximately four months at Coronado High School. Approximately 8-10 youth, parents or guardians of the youth, and 2-5 special education teachers and staff, will be participating in this study.

RISKS

If you decide to participate in this study, then you may face a risk of being identified as a participating teacher/staff member within your campus' community. However, any data collected from your participation in the sessions or in interviews will be kept confidential. The research has tried to reduce these risks by removing all linked identifiers from the data collected, keeping all tapes and hard copies of data in a locked cabinet in one of the investigator's locked offices, and maintaining all video data on password-protected computers.

BENEFITS

The possible/main benefits of your participation in the research are improvements in your students' social skills, as well as gained insights regarding yours and your students' teaching and learning styles. You may also discover new ways of incorporating visual media and technologies into your daily classroom practice. Finally, information gathered from your participation in the study will serve the larger education research community as it seeks to understand how interactive multimedia systems can benefit learners in special and general education classrooms alike.

CONFIDENTIALITY

All information obtained in this study is strictly confidential. The results of this research study may be used in reports, presentations, and publications, but the researchers will not identify you. In order to maintain confidentiality of your records, Lisa Tolentino will verify that participants are assigned an alternative name that will be kept on a separate computer from the actual video data. Each computer is password protected. These alternative names will be used during the video coding process. Only the necessary research staff will be given access.

In some cases such as a focus group it may not be possible to guarantee confidentiality. Due to the nature of the study, the research team cannot guarantee complete confidentiality of your data. It may be possible that others will know what you have reported.

WITHDRAWAL PRIVILEGE

Participation in this study is completely voluntary. It is ok for you to say no. Even if you say yes now, you are free to say no later, and withdraw from the study at any time.

Participation is voluntary and nonparticipation or withdrawal from the study will not affect your employment status. In addition, any transcribed interview data collected from you will be excluded from the study if you decide to withdraw.

COSTS AND PAYMENTS

There is no payment for your participation in the study. The researchers want your decision about participating in the study to be absolutely voluntary and recognize that your participation may pose an increase in your time and effort.

VOLUNTARY CONSENT

Any questions you have concerning the research study or your participation in the study, before or after your consent, will be answered by Elizabeth Kozleski, PO Box 876103, Tempe, AZ,

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85287-6103, (480) 965-0391, or Lisa Tolentino, PO Box 878709, Tempe, AZ 85287-8709, (661) 301-9856 or (480) 306-6458.
If you have questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk; you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at 480-965 6788.

This form explains the nature, demands, benefits and any risk of the project. By signing this form you agree knowingly to assume any risks involved. Remember, your participation is voluntary. You may choose not to participate or to withdraw your consent and discontinue participation at any time without penalty or loss of benefit. In signing this consent form, you are not waiving any legal claims, rights, or remedies. A copy of this consent form will be given (offered) to you.

Your signature below indicates that you consent to participate in the above study.

Subject's Signature	Printed Name	Date

INVESTIGATOR'S STATEMENT

"I certify that I have explained to the above individual the nature and purpose, the potential benefits and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature. These elements of Informed Consent conform to the Assurance given by Arizona State University to the Office for Human Research Protections to protect the rights of human subjects. I have provided (offered) the subject/participant a copy of this signed consent document."

Signature of Investigator________________________________ Date___________

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Date 10-10-11 to 10-9-12

APPENDIX C

INFORMED PARENTAL PERMISSION FORMS

INFORMED PARENTAL PERMISSION FORM
ARIZONA STATE UNIVERSITY

SEA OF SIGNS – AUGMENTED REALITY LEARNING IN SPECIAL EDUCATION

INTRODUCTION:
The purposes of this form are to provide information that may affect decisions regarding your child's participation and to record the consent of those who are willing for their child to participate in this study.

RESEARCHERS:
Elizabeth Kozleski, Professor, School of Social Transformation, and Lisa Tolentino, Doctoral Student, School of Arts, Media and Engineering (AME), at Arizona State University, have invited your minor child's participation in a research study at this institution.

DESCRIPTION OF RESEARCH STUDY:
If you decide to allow your child to participate in this study, your child will be asked to participate in a series of activities that take place in an innovative technology environment installed at your child's school. These activities have been designed in collaboration by a local team of special education teachers, education psychologists, and design researchers. The goal of the study is to determine if different kinds of dynamic media (i.e., moving pictures, graphics) that are triggered by one's voice can make a difference in supporting social engagement between youth. Approximately 8-10 students will participate in this study. Students will be divided into pairs and will work directly with the teacher in a session that lasts approximately 15 minutes. Your child's weekly participation will consist of 2-3 sessions that occur during regular class periods during the week, for up to 10 weeks during the regular school year. The study takes place in the school's Situated Multimedia Arts Learning Lab (SMALLab).

Each session will be videotaped and used solely for research purposes, to aid in identifying patterns or changes in behavior. The videotape will not be shared with anyone outside of our research team, and your child's participation in this study will be voluntary. The results of the study may be published, but your child's name and other identifying information will not be used out of protection of your child's dignity and privacy.

Prior to participation, your child's teacher will ask for your child's verbal assent prior to participation. If at any time, you or your child chooses to withdraw your child's participation at any time, there will be no penalty. Your decision regarding your child's participation will not affect his/her care or treatment during the program.

Your child will be asked to take his/her shoes off to keep SMALLab's padded floor clean (the floor is made of tiles of Wondermat, a soft, white, foam). Your child will participate in the activity with his/her classmates and teacher. During the activity, your child will be asked to use a voice controller that enables him to record and send messages to each other through SMALLab. Their voice will trigger visuals that are displayed on the floor. There may be soft or mild sounds that play. If any of it bothers your child, or the teacher/staff notices that it bothers your child, the student can sit out of the activity, or the teacher will walk with the student back to his/her regular classroom – whichever is most comfortable for your child. If this occurs, we will also make note of it and ask the child later why he/she was uncomfortable. In addition, we will let you know that this has occurred. At this time, you can also let us know whether you feel it would be in the best interest of your child to continue participating in the study.

Our primary goal is that your child is benefits from these designed activities. Due to a variety of individual learning styles between students, it is possible that your child may not receive direct or full benefit. Your child's participation, however, still contributes valuable information to the greater education research community interest in understanding how interactive multimedia systems can support learning for youth with physical or cognitive disabilities.

EXCLUSIONARY CRITERIA:
In order for your child to participate in this study, your child must be a student receiving education in the special education class. There are no other exclusionary criteria.

RISKS:
We are aware that many of our participating students may have the autism label, which may indicate that a child has multisensory challenges (e.g., difficulty processing sound and visuals that are independent of each other, loud sounds, etc.). As a result, we have designed the scenario to use projected visual displays with simple graphics or pictures of students' faces, and the images are slow to transition or change. These graphics will be displayed on the floor. There is also minimal sound playback – only the children's own voices at a mild, adjustable volume. Unless your child is sensitive to visual displays, there are no known or foreseeable risks for taking part in this study.

If you decide to let your child participate in this study, your child will be in situations that include typical daily activities like asking and answering questions in class, and passing a shared object around to peers. As with any research, there is some possibility that your child may be subject to risks that have not yet been identified.

BENEFITS:
The possible benefits of your child's participation in the research are increased practice in sharing and social communication, increased self-awareness and peer-awareness, and strengthened relationships between peers and teachers. Teachers may also gain insights into how your child learns. Benefits to society may include the development of new strategies for designing computer-based technologies for special and general educational settings. This research may also inspire new interest in human-computer interaction research and design that builds upon the lived experience of youth with disabilities.

NEW INFORMATION:
You will be contacted if new information is discovered that would reasonably change your decision about your child's participation in this study.

CONFIDENTIALITY:
All information obtained in this study is strictly confidential unless disclosure is required by law. The results of the research study may be published but your child's name or identity will not be revealed. In order to maintain confidentiality of your child's records, the investigators will dissociate students' and teachers' names from the data by assigning pseudonyms. All data and tapes will be securely locked in a cabinet in a private department office equipped with an alarm system. Names and any other personal information will never be disclosed to anyone other than the co-investigators of the research team. Data being reviewed or analyzed on a computer (such as video data) will be stored and encrypted on a computer that is only/exclusively available to the co-investigators via password. All data will be destroyed 5 years

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after the completion of the final data analysis: paper documents will be shredded, and videotapes and data files will be erased.

WITHDRAWAL PRIVILEGE:
If you choose not to have your child participate or to withdraw your child from the study at any time, there will be no penalty. It will not affect your child's grade or treatment in class. Likewise, if your child chooses not to participate or to withdraw from the study at any time, there will be no penalty. Your child's participation is voluntary, and non-participation or withdrawal from the study will not affect your child's grade or treatment by his/her teachers and staff.

COSTS AND PAYMENTS:
The researchers want your decision about your child participating in the study to be absolutely voluntary. There is no payment for your child's participation in the study; however, the researchers express their gratitude for your child's participation and welcome any questions, concerns, or feedback you may have. Similarly, you are welcome to schedule a visit to experience the activity that your child will participate in.

COMPENSATION FOR ILLNESS AND INJURY:
Agreeing to your child's participation does not waive any of your legal rights. However, no funds have been set aside to compensate you in the event of injury. In the event that your child suffers harm as a result of participation in this research project, you may contact Elizabeth Kozleski (480-965-0391) or Lisa Tolentino (661-301-9856 / 480-306-6458).

VOLUNTARY CONSENT: By signing this form, you are saying (1) that you have read this form or have had it read to you, and (2) that you are satisfied you understand this form, the research study, and its risks and benefits. The researchers will be happy to answer any questions you have about the research. If you have any questions, please feel free to contact Elizabeth Kozleski (480-965-0391) or Lisa Tolentino (661-301-9856 / 480-306-6458).

If at any time you feel pressured to allow your child to participate, or if you have any questions about your rights or this form, please call the Chair of the Human Subjects Institutional Review Board through the ASU Office of Research Integrity and Assurance at (480) 965-6788.

Note: By signing below, you are telling the researchers Yes, that you will allow your child to participate in this study. Please keep one copy of this form for your records.

Your child's name (please print): ____________________

Parent 1: Your name (please print): ____________________

Your Signature: ____________________

Parent 2: Your name (please print): ____________________

Your Signature: ____________________

Date: ____________________

INVESTIGATOR'S STATEMENT:

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I certify that this form includes all information concerning the study relevant to the protection of the rights of the participants, including the nature and purpose of this research, benefits, risks, costs, and any experimental procedures.

I have described the rights and protections afforded to human research participants and have done nothing to pressure, coerce, or falsely entice the parent to allowing this child to participate. I am available to answer the parent's questions and have encouraged him/her to ask additional questions at any time during the course of the study.

Investigator's Signature: ______________________________

Date: ______________________________

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Approved
Sign Stefan Mark Roos
Date 12/12/11 - 10/9/12

親権同意書
アリゾナ州立大学

シー・オブ・サインー特殊教育における実践型学習の増加

<u>本同意書について</u>
本同意書は、お子様が、後に説明される研究調査への参加の是非を判断するのに必要な情報を提供するものであり、参加を許可された場合には、お子様の本研究調査へ参加同意を記録するものである。

<u>当研究調査について</u>:
アリゾナ州立大学ソーシャルトランスフォーメーション学部(School of Social Transformation)に所属のエリザベス・コズレスキー（Elizabeth Kozleski）教授および、同大学芸術・メディア・エンジニア学部(School of Arts, Media and Engineering)所属のリサ・トレンチノ（ Lisa Tolentino）博士によって行われる研究調査である。本研究調査は当大学のために行われるものであり、貴方のお子様の参加を歓迎している。

<u>研究調査詳細について</u>:
お子様の参加を許可された際には、お子様は校内の、革新技術が完備された施設で行われる一連の活動に参加することになる。これらの活動は当地の特殊教育の先生、教育心理学者、およびデザイン研究者の協力によって構成されたものである。本研究の目的は、同音声を使用した異なる動的なメディア(例：動画、画像)が若者の社会的結束力与える影響の違いを明らかにするものである。
本調査の募集人数は8－10人とされている。お子様は2人1組に分かれ、約15分行われるセッションで指導者と連携して作業に取り組むことになる。調査活動は学校の通常授業が行われる期間内で、毎週2－3セッション行われ、一年間最多で10週までとされる。調査は学内のシチュエーティッドマルチメディアアーツラーニングラボ(Situated Multimedia Arts Learning Lab, (SMALLab))で行われる。すべてのセッションは録画され、お子様の行動パターンや変化といった分析研究目的のためだけに使用される。録画された映像は研究チーム以外の者に使用されることはない。本研究への参加は任意的なものである。研究結果は公表されることはありうるが、お子様の名前やその他の個人情報は保護される。
本調査の参加前に、担当指導者はお子様に口頭で参加同意を尋ねることになる。いかなる時においても、貴方の、或いはお子様の意思により本研究への参加取り消しを行っても罰則は課されない。お子様の本研究への参加に対する貴方の意見は、セッションにおけるお子様への待遇に影響を与えない。
お子様はSMALLabに入る際に、清潔保護のため靴を脱ぐことになる(ワンダーマートタイルという、柔らかくて白い発泡剤による床が設置されてある)。お子様は自分のクラスメートや指導教官と本活動に参加することになる。活動中、お子様はSMALLab内で音声制御装置を使って、メッセージを保存したり、他学生とメッセージのやり取りをすることになる。それらの音声によって床に画像が表示され、室内に静かで穏やかな音が流れる。もしこれらのことによりお子様に何らかの影響を与えた場合、或いは担当指導者及びスタッフがお子様の異常を気付いた場合には、お子様は活動から退出、或いは指導者とともに通常の教室へ戻ることができる。いずれの選択肢を、お子様は自分の意思で選択できる。その際、当事情について記録を残し、後に

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その原因についてお子様に伺う。また、当事情を親に説明し、親はお子様の当調査への参加継続について決める権利が持つものとする。

我々の主な目的は、お子様がこれらの活動を通じて便益を得ることである。子供の学習スタイルは人それぞれ異なるため、お子様は本活動にて思うような成果を挙げられないことも考えられる。しかしその際でも、お子様の本研究への参加は貴重な情報を提供してくれるものであり、それにより、双方向のマルチメディアシステムが若年層の身体・認知障害者の学習に働きかけるサポートなどに関する研究の発展につながることをご理解いただければ幸いである。

研究調査参加条件:

お子様が本調査に参加される、お子様は特殊教育授業で教育を受けている学生でなければならない。それ以外の条件はないものとする。

リスクについて:

我々は参加者の学生が自閉症である可能性も踏まえ、多種知覚における不都合を考慮に入れている(例：互いに独立した音や画像の処理の困難や、大音量など)。そのため、我々はシンプルな画像や学生の顔写真を使った視覚表示を計画し、画像の切り替えを低速度で行う。これらの画像は床上に表示される。また、静かな音が流されるが、それはお子様自身の声で、穏やかに調整された音声である。お子様が視覚表示に過敏でない限り、本研究調査におけるリスクはないものだと考えられている。

お子様の当研究調査への参加を許可した場合には、お子様は通常授業で質問の作成および回答、または仲間と共有物の分け合いが求められる。その他の研究調査と同様、予測できないリスクが生じる可能性があることを、ご理解いただければ幸いである。

利点について:

お子様が本調査で得られる便益としては、社交性の向上、自己認識力および周囲認識力の改善、仲間や教師との絆の強化などが考えられる。教師はお子様の学習方法の詳細まで観察することもある。本研究調査の社会へ対する利益としては、特殊および一般教育の教材のために必要なコンピューター技術の開発が考えられる。また、本調査は人間とコンピューターの相互作用に関する研究および構築に対する関心の拡大につながると考えられる。

情報の更新について:

新たな情報が発生した際、それらがお子様の本研究への参加継続を影響するものと判断された場合には、我々は貴方にその皆を連絡する。

個人情報保管について:

本調査で得られたすべてのデータは、法的な開示要求がない限り、厳重に保管されるものとする。研究結果は公表されることはありうるが、お子様の姓名およびその他の個人情報は公表されることはない。お子様の記録の秘密性を保持するため、研究者は学生および教師に関するデータの取り扱いの際には、匿名を使用する。すべてのデータ及びビデオテープは警報機が完備された事務所の倉庫に厳重に保管される。姓名およびその他の個人情報は研究者チーム内の共同研究者以外の者に公開することはない。コンピューターで取り扱われるデータは、パスワ

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Sign [signature] Mark Ryoda
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ードによって共同研究者だけが使用可能な、暗号化されたコンピューターに保存される。すべてのデータは最終分析が行われた5年後に破棄される。また、印刷書類はシュレッダー処理を行い、ビデオテープおよびデータファイルは削除される。

調査参加の脱退について:

貴方が、お子様の本研究への参加の取消し、或いは脱退を決意した場合には、決定時期を問わず、罰則は与えられない。また、その行為はお子様の成績および授業での待遇には影響を与えない。同様にお子様が本研究調査への不参加、および脱退を決定した際にも、時期を問わず罰則は与えられない。お子様の本研究調査への参加は任意なものであり、不参加および脱退は、お子様の成績、あるいは教師やスタッフからの待遇に影響を与えないものである。

費用および報酬について:

研究者は、貴方のお子様の本研究調査への参加許可を任意的なものであると望んでいる。そのため、お子様が本研究調査への参加において、報酬はないものとする。ただし、研究者はお子様の参加に感謝を示し、いかなる質問、相談、意見を歓迎する。同様に、貴方もお子様が参加される活動への見学に歓迎される。

病気および怪我の賠償について:

お子様の本研究調査への参加同意は、貴方の法的権利には影響を与えない。ただし、活動中の怪我に対する賠償金は出ないものとされる。本研究調査への参加により、活動中に怪我された場合には、エリザベス・コズレスキー (Elizabeth Kozleski, 480-965-0391)、あるいはリサ・トレンチノ(Lisa Tolentino, 661-301-9856 / 480-306-6458)に連絡し、相談することが可能である。

自由意思の承諾について:

この書類にサインすることにより、貴方は (1)本同意書を熟読したものとし、(2)本同意書の内容、本研究調査の内容、利点およびリスクを十分に理解したものと表明する。研究者は本研究に関するいなかる質問を受け付けており、質問がある際にはご遠慮なく、エリザベス・コズレスキー (Elizabeth Kozleski, 480-965-0391)、あるいはリサ・トレンチノ(Lisa Tolentino, 661-301-9856 / 480-306-6458)へ連絡することが可能である。

お子様の本研究への参加において、不安が生じた場合、また、本同意書に関する自身の権利について不明な点がある際は、アリゾナ州立大研究保全保障事務所(ASU Office of Research Integrity and Assurance)を通し、人臣施設概観議会議長(Chair of the Human Subjects Institutional Review Board, 480-965-6788) に相談することが可能である。

※本同意書にサインすることで、お子様の本研究への参加を同意するものとする。また、コピーを一部取り、手元に保管することが必須である。

お子様の姓名 (印刷) : ______________________

親1: 姓名 (印刷) : ______________________

サイン : ______________________

親2: 姓名 (印刷) : ______________________

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サイン：　＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

日付：　＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

<u>調査者の声明</u>:

私は本同意書には、本研究調査に関する参加者の権利の保護、研究の性質および目的、利点、リスク、費用、そして手法のすべての情報が記載されていることを保証する。

私は本研究調査参加者の全ての権利および保護について記載しており、親に対しお子様の本研究への参加の強制、強要、または悪質な勧誘を一切行っていない。私は調査期間中、親からのあらゆる質問に答える準備をしており、また、追加質問を奨励する。

調査者サイン:　＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

日付:　＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿＿

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Date 12/12/11 - 10/9/12

FORMULARIO PARA OBTENER EL PERMISO DE LOS PADRES
Arizona State University (Universidad Estatal de Arizona)

Sea of Signs (Mar de signos) - REALIDAD AUMENTADA EN EL APRENDIZAJE DE EDUCACIÓN ESPECIAL

INTRODUCCIÓN:
El propósito de este formulario es proporcionar información que pueda influir en las decisiones relativas a la participación de su hijo y para registrar el consentimiento de aquellos que están dispuestos a que su hijo participe en este estudio.

INVESTIGADORES:
Elizabeth Kozleski, Profesora de la Escuela de Transformación Social, y Lisa Tolentino, estudiante de doctorado de la Facultad de Artes, Medios de Comunicación e Ingeniería (AME), Arizona State University, han invitado su hijo, menor de edad, que participe en un estudio de investigación en esta institución.

DESCRIPCIÓN DEL ESTUDIO DE INVESTIGACIÓN:
Si usted decide permitir que su hijo participe en este estudio, su hijo tendrá que participar en una serie de actividades que tienen lugar en un entorno de innovación tecnológica instalada en la escuela de su hijo. Estas actividades han sido diseñadas en colaboración por un equipo local de los maestros de educación especial, psicólogos educativos, y los investigadores de diseño. El objetivo del estudio es determinar si ambos tipos de medios dinámicos (es decir, imágenes animadas y gráficos) que se activan por la voz pueden marcar la diferencia en el apoyo a la participación social entre los jóvenes. Aproximadamente entre 10-80 estudiantes participarán en este estudio. Los alumnos se dividirán en parejas y trabajarán directamente con el profesor en una sesión que dura aproximadamente 15 minutos. La participación semanal de su hijo consistirá en 2-3 sesiones que se desarrollan durante las clases regulares por la semana, y que durará un máximo de 10 semanas durante el año escolar. El estudio se lleva a cabo en la escuela de Artes y Multimedia en el Laboratorio de Aprendizaje (SMALLab).

Cada sesión será grabada en vídeo y se utiliza exclusivamente con fines de investigación, para ayudar en la identificación de cambios en el comportamiento. El video no será compartida con nadie fuera de nuestro equipo de investigación, y la participación de su hijo en este estudio será voluntario. Los resultados del estudio pueden ser publicados, pero el nombre de su hijo y otra información privada que los pueda identificar no serán utilizados fuera de la protección de la dignidad de su hijo y la privacidad.

Antes de la participación, el maestro de su hijo le pidará consentimiento verbal de su hijo. Si en cualquier momento, usted o su hijo decide retirar la participación de su hijo, no habrá penalización. Su decisión respecto a la participación de su hijo no afectará a su atención o tratamiento durante el programa.

Su hijo tendrá que quitarse sus zapatos para mantener limpio el suelo acolchado de SMALLab (el piso es de baldosas de Wondermat, un paño suave, espuma blanca,). Su hijo participará en la actividad con sus compañeros y maestros. Durante la actividad, su hijo tendrá que utilizar un controlador de voz que le permite grabar y enviar mensajes a través SMALLab. Su voz activará imágenes que se proyectan en el suelo. Es posible que sonidos suaves toquen. Si eso incomoda a su hijo o si los profesores se dan cuenta que le hace daño a su hijo, el estudiante puede sentarse fuera de la actividad, o el profesor acompañará a su hijo devuelta a la clase regular – lo que sea más cómodo para su hijo. Si esto ocurre, también vamos a tomar nota de ello y pedir al niño más adelante por qué se sentía incómodo. Además, se le hará saber que esto ha ocurrido. En este momento, también puede dejarnos saber si usted se siente que sería en el mejor interés de su hijo a no seguir participando en el estudio.

Nuestro objetivo principal es que su hijo se beneficie de estas actividades. Debido a una variedad de estilos individuales de aprendizaje entre los estudiantes, es posible que su hijo no reciba beneficio directo o completo. Sin embargo, participación de su hijo aportará información valiosa para el interés de la comunidad de educación superior de investigación en la comprensión de cómo los sistemas interactivos de multimedia pueden apoyar el aprendizaje de los jóvenes con discapacidades físicas o cognitivas.

CRITERIOS DE EXCLUSIÓN:
Para que su hijo participe en este estudio, su hijo debe ser un estudiante que está clasificado para recibir educación especial. No hay otros criterios de exclusión.

RIESGOS:
Somos conscientes de que muchos de nuestros estudiantes pueden tener autismo, lo que puede indicar que un niño tiene problemas multisensoriales (por ejemplo, dificultad para procesar el sonido y las imágenes que son independientes de cada uno de otros sonidos, sonidos fuertes, etc.) Como resultado de ello, hemos diseñado el escenario para el uso de los visuales proyectados con gráficos simples o imágenes de los rostros de los estudiantes, y las imágenes cambian lentamente. Estas imágenes se mostrarán en el piso. También hay un mínimo nivel de reproducción de sonido - sólo las voces de los propios niños se sentirán a un nivel de volumen bajo y ajustable. A menos que su hijo es sensible contra las pantallas visuales, no hay riesgos previsibles para tomar parte en este estudio.

Si usted decide que su hijo puede participar en este estudio, su hijo estará en una situación típicas que incluye actividades diarias como hacer y responder preguntas en la clase y pasar un objeto compartido en torno a sus compañeros. Con cualquier investigación, hay posibilidad de que su hijo pueda estar sujeto a los riesgos que aún no han sido identificados.

BENEFICIOS:
Los posibles beneficios de la participación de su hijo en la investigación son el aumento en la práctica del intercambio y la comunicación social, conocimiento de sí mismo y de sus otros compañeros y fortalecimiento de las relaciones entre compañeros y maestros. Los maestros también pueden hacerse una idea de cómo aprende su hijo. Beneficios para la sociedad puede incluir el desarrollo de nuevas estrategias para el diseño de las tecnologías informáticas de los centros educativos especiales y generales. Esta investigación también podría inspirar un nuevo interés en la investigación de la interacción entre el ser humano y el computador y un diseño que se basa en la experiencia vivida por los jóvenes con discapacidades.

NUEVA INFORMACIÓN:
Nos comunicaremos con usted si se descubre nueva información que razonablemente cambie su decisión sobre la participación de su hijo en este estudio.

CONFIDENCIALIDAD:
Toda la información obtenida en este estudio es estrictamente confidencial a menos que la revelación es requerida por la ley. Los resultados de la investigación pueden ser publicados, pero el nombre de su hijo o identidad no será revelada. Con el hecho de mantener la confidencialidad de los registros de su hijo, los investigadores usarán seudónimos en vez de los

nombres de los profesores y de su hijo. Todos los datos y las grabaciones estarán bajo llave en un armario en la oficina privada del departamento, equipado con un sistema de alarma. Los nombres y otra información personal nunca serán reveladas a nadie más que a los co-investigadores del equipo de investigación. Datos que se están examinados o analizados en un computador (por ejemplo, los datos de video) serán almacenados y cifrados con de contraseña en una máquina que sólo estará a la disposición exclusiva de los co-investigadores. Todos los datos serán destruidos cinco años después de la finalización del análisis de los datos finales: los documentos en papel serán destrozados, y los vídeos y archivos de datos se borrarán.

RETIRO DE PRIVILEGIO:
Si opta por no dejar a su hijo participar o si retira a su hijo del estudio en cualquier momento, no habrá penalización. No afectará a la nota de su hijo o de su tratamiento en la clase. De la misma manera, si su hijo decide no participar o retirarse del estudio en cualquier momento, no habrá penalización. Participación de su hijo es voluntaria, y la falta de participación del estudio no afectará a la nota de su hijo o el tratamiento por sus maestros.

COSTOS Y PAGOS:
Los investigadores quieren que su decisión acerca de su hijo participar en el estudio sea absolutamente voluntaria. No hay pagamiento por la participación de su hijo en el estudio, sin embargo, los investigadores expresan agradecimiento por la participación de su hijo y la bienvenida a cualquier pregunta, duda o comentario que usted pueda tener. De la mismo manera, le invitamos que haga una visita a SMALLab para ver la actividad en cual su hijo va a participar.

INDEMNIZACIÓN POR ENFERMEDAD Y LAS LESIONES:
Estar de acuerdo a que su hijo participe no renuncia a ninguno de sus derechos legales. Sin embargo, no se han reservado dinero o compensación monetaria para compensarle en caso de lesión. En el caso de que su hijo se lastime como consecuencia de la participación en este proyecto de investigación, puede comunicarse con Elizabeth Kozleski (480-965-0391) o Lisa Tolentino (661-301-9856 / 480-306-6458).

CONSENTIMIENTO VOLUNTARIO
Al firmar este formulario, usted está diciendo (1) que ha leído este formulario o lo han leído a usted, y (2) que está satisfecho de entender lo que dice este formulario sobre el estudio de investigación, y sus riesgos y beneficios. Los investigadores estarán dispuestos a contestarle cualquier pregunta que tenga sobre la investigación. Si usted tiene alguna pregunta, no dude en ponerse en contacto con Elizabeth Kozleski (480-965-0391) o Lisa Tolentino (661-301-9856 / 480-306-6458).

Si en algún momento se siente presionado para permitir a que su hijo participe, o si tiene alguna pregunta acerca de sus derechos o de este formulario, favor de llamar al Director de la Junta Institucional de Revisión de Sujetos Humanos a través de la Oficina "ASU de Integridad en la Investigación y Aseguramiento" (ASU Office of Research Integrity and Assurance) al (480-965-6788).

Nota: Al firmar abajo, usted está diciendo a los investigadores que Sí, le permitirá a su hijo a participar en este estudio. Por favor, mantenga una copia de este formulario para sus registros.

Nombre de su hijo (escribir de manera legible): ______________________________

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Date 12/12/11 - 10/9/12

Padre 1: Su nombre (escribir de manera legible): ______________________________

Su firma: ______________________________

Padre 2: Su nombre (escribir de manera legible): ______________________________

Su firma: ______________________________

Fecha: ______________________________

DECLARACIÓN DEL INVESTIGADOR:
Certifico que este formulario incluye a toda la información sobre el estudio pertinente para la protección de los derechos de los participantes, incluyendo al propósito de esta investigación, los beneficios, los riesgos, los costos y cualquier procedimiento experimental.

He descrito los derechos y las protecciones dadas a los participantes en la investigación humana y no he hecho nada para presionar, coaccionar, o falsamente atraer a los padres a que permitan a este niño participar. Estoy disponible para contestar las preguntas de los padres y le animo a que haga preguntas adicionales en cualquier momento durante el transcurso del estudio.

Firma del Investigador: ______________________________

Fecha: ______________________________

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Date <u>12/12/11 - 10/4/12</u>

APPENDIX D

CHILD ASSENT FORM

CHILD VERBAL ASSENT SCRIPT

Study: Sea of Signs - Augmented Reality Learning in Special Education

I have been told that my parents (mom or dad) have said it's okay for me to take part in a project in SMALLab. In this project, I will practice speaking, and my voice will allow me to interact with images displayed on the floor.

I will be asked to take my shoes off to keep the padded floor of SMALLab clean. I will participate in the activity with my classmates and teacher. During the activity, I will be asked to use a voice controller that lets me record and send messages in SMALLab. There will be visuals displayed on the floor. There may be soft or mild sounds that play. If any of it bothers me, or my teacher notices it bothers me, I am allowed to sit out the activity or return to my regular classroom.

I will only be in SMALLab for one part of one class period, 2 or 3 times per week.

I am taking part because I want to. I know that I can stop at any time if I want and it will be okay if I want to stop.

______________________________ ______________________________

Sign your name here (if your are able) Print Your Name Here

NOTE: If student cannot sign, but has given verbal assent, teacher will sign.

______________________________ ______________________________

Student's name Teacher's Signature

____

Date

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Date 10-10-11 to 10-9-12

APPENDIX E

SITUATED MULTIMEDIA ART LEARNING LAB INFRASTRUCTURE

This section describes the technical configuration and infrastructure of the Situated Multimedia Art Learning Lab (SMALLab). The following image shows a representation of the SMALLab system (Birchfield, Ciufo, & Minyard, 2006; Birchfield et al., 2008). It is comprised of 10 motion-tracking cameras (in red), a projector mounted to the ceiling and displaying on the floor, four generic speakers mounted at the corners of the space, and a soft white floor for the projection. Motion-tracking software interprets object data and broadcasts object movement data to a network of computers over User Datagram Protocol (UDP). This data made available by UDP to input into the audio-visual feedback and data archive. Incoming data can then be filtered and processed to control or manipulate feedback.

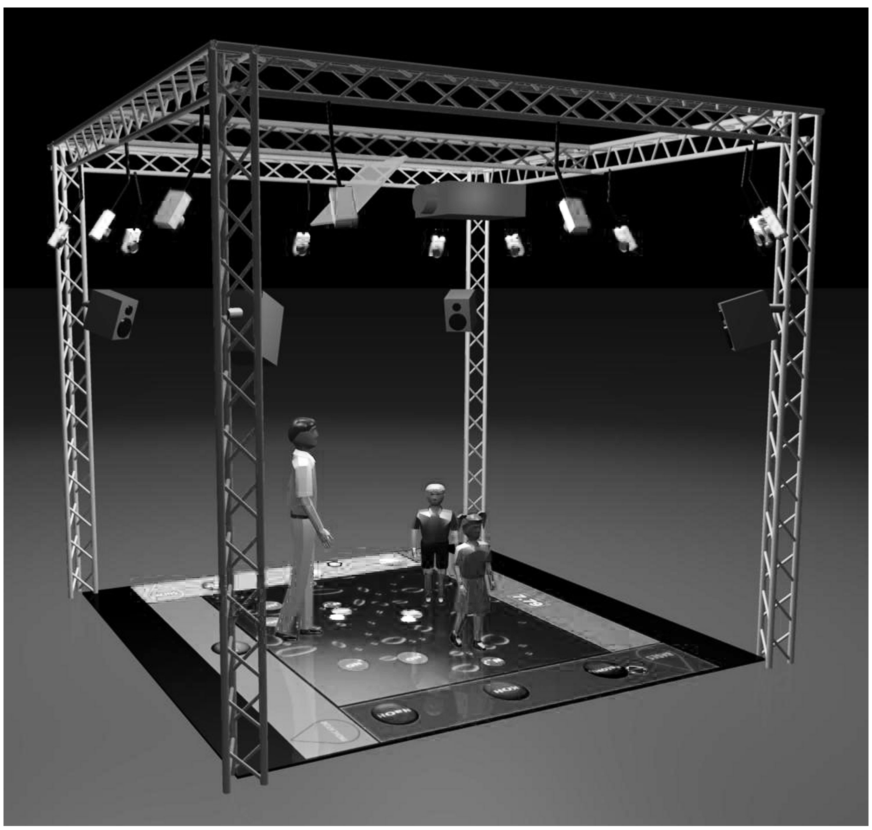

***Figure 41*. SMALLab infrastructure with trellis for mounting motion-capture system. Image courtesy of David Tinapple.**

***Figure 42*. Trackable objects and peripherals. Two wands (top two photos) have infrared marker balls mounted in unique geometries to allow the Optitrack cameras to distinguish between them. Motion tracking software calculates each object's position and rotation data, which is then passed across the local network via UDP. Infrared markers are placed on the iRobot (bottom left), which can be controlled using Bluetooth. The Logitech Gamepad (bottom right) can be used to change SMALLab scenes and feedback.**

***Figure 43*. SMALLab installed without trellis. In this picture, SMALLab is installed without the trellis, leaving the space open on all sides, allowing participants to freely move in and out of the space.**

***Figure 44*. SMALLab monitoring station. The station is set to the side of the SMALLab space, to allow researchers and designers to monitor the system and make changes.**

A basic SMALLab installation requires:

- A machine for audio-visual feedback. Here, Mac OS X is used along with standard monitor displays and keyboards, running the Unity3D Game Engine software[15].
- A machine for motion-capture, running Windows machine running NaturalPoint's Tracking Tools software for use with OptiTrack[16] motion-capture infrared cameras.
- 10 OptiTrack cameras daisy-chained together through Firewire, attached to a raised classroom ceiling, and routed via Firewire to the Windows machine.
- A ceiling mounted projector pointing toward a mirror at an angle, creating a large top-down floor display.
- Four ceiling mounted speakers in each corner of SMALLab, angled toward the center of the space.
- A soft white padded floor made of SoftTiles: http://www.softtiles.com/
- One network hub linking the audio-visual feedback and motion-capture machines together.

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[15] The Unity3D Game Engine software for developing games is offered in both free and paid versions, at http://unity3d.com/, accessed April 7, 2013.

[16] OptiTrack motion capture product website, http://www.naturalpoint.com/optitrack/, accessed April 7, 2013.

- An audio interface, connecting four monitor speakers suspended in the four corners of SMALLab.

***Figure 45*. Tan circle rugs with cardboard wings. Rugs, approximately 2.5 feet in diameter, with cardboard wings serving as tracked objects for placing Velcro balls with reflective tape. At the center of the floor is a custom-built seashell shaped object that contains a wireless microphone unit. This object is also being tracked via motion capture and has two Velcro balls placed on top.**

Hardware elements added to SMALLab for the *Sea of Signs* scenario included:

- PureData for audio analysis and feedback.
- A wireless microphone system patched into the sound interface. Here, the wireless microphone is embedded in a sea-shell shaped object.
- A nautilus-shaped shell object, approximately 8” x 10” with a 2.5” diameter. The shell contains two seamless magnetic enclosures on either side for inserting and concealing a wireless microphone element.
- Two light tan-colored, circular rugs, 2’4” in diameter. Taped beneath each rug was an extended piece of firm cardstock, where three reflective markers were Velcro-ed onto the cardstock and spaced far enough to be tracked by the motion capture cameras.

Software and Data Transmission. Three kinds of software were used in SMALLab. Optitrack was used to provide motion-capture capabilities, for collecting and transmitting movement data captured in the SMALLab space. Optitrack uses multicasting and dedicated ports to stream real-time data over the SMALLab system's network. PureData (Pd), a graphical programming environment for creating interactive computer music pieces, was used to provide a real-time sound analysis and synthesis of vocal input. PureData information was sent through to transmit audio data information to a dedicated socket in Unity3D, to drive visual feedback.

Unity3D, which is a game development tool with built-in physics engine, allowed for integrated media authoring (e.g., data-driven visuals and interactivity) and the ability to connect to other software through scripting. Unity3D received data from both Optitrack and PureData. C# scripting was used to scale and smooth data to dynamically control visual feedback projections for SMALLab space.

The wireless microphone signal was analyzed for pitch, loudness, and length of overall speech duration during a turn, using Miller Puckette's open source audio software, PureData[17]. Three features of the voice were used to drive changes in the visual particle systems based on. First, the rate of change in vocal pitch was mapped to color, such that if a speaking person's average pitch range remained monotone, the particle colors would also be monotone. By contrast, if a person spoke using a broad range of voicing, the result would be multiple colors. This was a way to reinforce participants' efforts to exercise their vocal range. Second, the amplitude or loudness of voice was mapped to the size of particles to visually reinforce and amplify louder speaking volume. A quieter voice yielded small particles, versus a louder one, which yielded larger particles. Finally, **t**he length of overall speech during a turn was used more subtly, to generate slightly faster streams of particles, indicating vocal input was more fluid, in order to encourage speaking for longer periods of time.

[17] PureData (Pd) downloads and updates are open source and hosted by the PureData community forum, http://puredata.info/, accessed April 7, 2013; and PureData creator Miller Puckette's website, http://crca.ucsd.edu/~msp/software.html, accessed April 7, 2013.

APPENDIX F

TEACHER VERBAL INTERVIEW QUESTIONS

The goal of these informal interviews was to gather a clearer picture regarding the cognitive levels of youth (e.g., their preferences, their learning styles, how they problem solve during a typical day). I focused specifically on eliciting examples of the child's communicative intent and mastery in the classroom, and in relation to others. Worksheets from the SCERTS Model (Prizant, Wetherby, Rubin, Laurent, & Rydell, 2006) were used to guide the questions.

Prior to scheduling interviews with teacher and staff, each teacher/staff participant was provided with a Teacher/Staff Consent Form. Participants were made aware that participation would be voluntary, that interviews would be video or audio taped, and that they may ask to stop recording at any time. I also offered to provide them with a transcription if they would like to review or correct their response for errors or clarification.

Teacher/staff were asked to join in up to three (3) sets of questions:

1) Pre-Experiment Interview focus group (60-90 minutes)
    a. To gather information about the cognitive processing of each child.

2) SMALLab debriefing focus group (15-20 minutes for each session)
    a. To gather observations regarding each SMALLab session.

3) Post-experiment focus group (60-90 minutes)
    a. To gather reflections about the technology, study, and perceived impact on youth.

I interviewed the primary collaborating teacher and staff member.

1. Pre-experiment interview example questions included:
    - What do we know already about the child (from classroom, IEP, diagnosis)?
    - What is he/she focused on?
    - What does a typical day look like for him/her?
    - What does he/she spend most of his time working on?
    - How does he/she communicate in the classroom?
        - Does he/she initiate communication with you or other staff? And how?
        - Does he initiate communication or interact with peers? With whom and how? (Note: identifiers will replace actual names)
    - What is his/her preference for leisure time?

- How does he/she solve problems? And what are some examples?
- What percentage of every hour does he/she engage in (e.g.,) echolalic talk?
- What individual or group communication activities do you use with the kids, and what does it look like? (who participates, nature of communication, requires lots of or minimal prompting)

2. SMALLab debriefing focus group example questions included:
   - What did you notice about child A's / child B's interactions today?
   - What were they successful at? What did they have trouble with?
   - I observed (events, occurrences) in today's session; did you notice these as well? If yes, why do you think they occurred?

3. Post-experiment focus group example questions included:
   - In what ways did you feel the technology aided or hindered social engagement?
   - Which features of the design did you perceive to be most successful? Least successful? How and why?
   - Did you feel that some features work better or worse for some students than others? Which ones and why?
   - In what ways did you feel your interaction with students was different or similar to your typical interactions with students in the classroom?
   - In a future experiment using this system or a modified version of it, what would you do differently? What would you modify? And what would you preserve?

BIOGRAPHICAL SKETCH

Lisa Tolentino is an interaction designer, media arts researcher, and experimental musician/percussionist. She earned her PhD in Media Arts and Sciences from the School of Arts, Media, and Engineering (AME) at Arizona State University. At ASU, her doctoral work focused on collaborating with special education teachers to create immersive, embodied learning experiences that used the SMALLab platform to support social interaction and communication for high school youth with autism. As a member of the greater K-12 Embodied and Mediated Learning Group, under the direction of David Birchfield, she co-developed learning scenarios for high school science education and collaborated with designers at the Institute of Play in New York City to develop game-based learning scenarios.

Prior to ASU, Lisa earned her B.S. in Computer Science from University of California, San Diego (UCSD), and conducted research on meaning and metaphor with the late computer science professor Joseph Goguen. She then earned her M.A. in Contemporary Music Performance from UCSD and performed regularly with the *redfish bluefish* percussion group, under the direction of Steven Schick.

Lisa has performed both nationally and internationally at festivals including the Agora Festival in Paris; Los Angeles Philharmonic's Green Umbrella Series; Tune-In Music Festival in New York; La Jolla Music Society's Summerfest; CalArts' Dog Star Orchestra; and Phoenix Experimental Arts Festival. She has recorded with Mode Records and recently completed a documentary film and recording project playing works by composer John Luther Adams. In addition, she belongs to the *Pakaraguian Kulintang Ensemble*, a San-Diego based group performing indigenous gong music from the southern Philippines.

Lisa currently plays with Phoenix's premier contemporary music ensemble, *Crossing 32nd Street*, and *Rules of Play*, a percussion-voice duo with Robert Esler. She is on the board of directors for *urbanSTEW*, a collective of artists and performers seeking to increase the local creation and awareness of digital arts in Arizona. In fall of 2013, she will join Phoenix Country Day School's faculty to develop an integrated arts-science-technology program.