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ORIGINAL PAPER

Preliminary Findings of a Telehealth Approach to Parent Training in Autism

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Abstract Telehealth or online communication technologies may lessen the gap between intervention requirements for children with autism spectrum disorders (ASDs) and the available resources to provide these services. This study used a video conferencing and self-guided website to provide parent training in the homes of children with ASD. The first eight families to complete the 12-week online intervention and three-month follow up period served as pilot data. Parents' intervention skills and engagement with the website, as well as children's verbal language and joint attention skills were assessed. Preliminary research suggests telehealth may support parental learning and improve child behaviors for some families. This initial assessment of new technologies for making parent training resources available to families with ASD merits further, in-depth study.

Keywords Telehealth · Computers/internet · Parent training · Autism spectrum disorder

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Introduction

Recent epidemiological reports now suggest that the overall estimated prevalence of autism spectrum disorders (ASDs) is one out of every 88 children (1 in 54 boys and 1 in 252 girls) living in the United States (Center for Disease Control and Prevention 2012). The new numbers represent a 78 % increase in autism over the previous 5 years and place major demands on medical, behavioral, educational, and family services worldwide. Parents of children with ASD already experience seemingly insurmountable challenges, more so than families affected by other developmental disabilities when attempting to secure appropriate services (Kogan et al. 2008). With this most recent surge in incidence and limited resources, a potential outcome is that many children will not get the treatment and services they need and deserve. Thus as we continue to examine the potential causes of ASD, it is equally critical that we develop better models to ensure that effective interventions actually become implemented in the settings in which most children receive care.

The introduction and development of advanced technologies can provide alternatives and supplements to how services and treatments are delivered to those in need (Baggett et al. 2010). Telehealth is one mechanism that enables individuals to receive professional services and support at a distance. This may involve live video streaming to communicate in real time with a health care provider or interacting with online multimedia platforms to learn new information (Dudding 2009). The technology can be accessed at any time of day and in any location with basic, inexpensive equipment to customize the information relevant to the individual's learning needs and be shared across settings and people (Feil et al. 2008). Several studies involving telehealth have shown promise in teaching

behavior management strategies and general adaptive parenting techniques to low-income and/or young parents and those with children at risk for disruptive behavior (e.g., Baggett et al. 2010; Feil et al. 2008; Kacir and Gordon 1999; MacKenzie and Hilgedick 1999; Taylor et al. 2008). More recently, researchers have used telehealth for professional development and parent training in ASD (see Boisvert et al. 2010; Wainer and Ingersoll 2011 for reviews). For example, Hamad et al. (2010) trained 51 professionals, paraprofessionals, and family members in principles and procedures of Applied Behavior Analysis (ABA) using an online distance-learning course that included narrated slide presentations, video examples, and application exercises. Participants significantly increased their ABA knowledge from pre- to post-training and reported a high level of satisfaction with the online course. Similarly, Granpeesheh et al. (2010) found that an interactive online training program improved providers' knowledge of ABA principles and procedures.

Vismara et al. (2009b) compared the effectiveness of live video streaming and a self-directed DVD-based training program to an in-person didactic training in the Early Start Denver Model (ESDM; Rogers and Dawson 2010) with community early intervention providers. Both training approaches significantly increased providers' knowledge and skills in implementing the ESDM at fidelity, suggesting the potential cost and time-effectiveness of telehealth compared to traditional training methods. However, the majority of participants required continuous coaching and supervision (whether delivered remotely or in-person) to maintain correct implementation, which supports earlier findings about the importance of ongoing training to sustain new skills (Fixsen et al. 2009; Schoenwald et al. 2004; Wood et al. 2007).

In addition to telehealth training for professionals, researchers have begun to experiment with online modalities for teaching parents to implement autism-specific interventions. Currently, a self-directed DVD (Nefdt et al. 2010), web-based learning program (Jang et al. 2012), and "real-time" two-way video conferencing in families' homes (Baharav and Reiser 2010; Vismara et al. 2012) have been piloted and associated with increased parental skill in the implementation of the intervention. With approximately 71 % of US households having access to the Internet and nearly 83 % of adults able to do so from home, work, or elsewhere (U.S. Census Bureau 2009), telehealth may allow autism services and supports to be more widely available to families in areas where such opportunities might be limited. As technology develops, additional research will be necessary to identify reliable, valid, and affordable components of an evidence-based telehealth framework and intervention program for delivering services at a distance.

The present study used a telehealth program consisting of two-way, live video conferencing and a self-guided website to conduct parent training in the homes of families of young children with ASD. The first eight families to complete the 12-week telehealth intervention and three-month follow-up period as part of a larger randomized controlled trial (contrasting the telehealth intervention to an online control group) served as participants. Our research questions examined to what extent: (1) parents perceived the telehealth program as a useful learning platform for disseminating a parent training model; (2) parents' intervention skills and engagement style improved over time from the telehealth program; (3) parents' self-guided activity on the website assisted their learning and use of the intervention; and (4) children's verbal language and joint attention initiations improved from parent implementation. We discuss these findings in relation to our experiences and lessons learned from using telehealth to service families and the new research directions currently underway as a result of this piloting.

Methods

Participants

Participants consisted of eight children with ASD and at least one parent who expressed interest in learning the intervention and was available to participate in all of the telehealth sessions. The children were diagnosed by a licensed professional in the families' community (and uninvolved with the present study) and met DSM-IV criteria for autism as well as the cutoff for ASD on the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2002). Families met the following criteria for eligibility into the study: (a) children no older than 48 months of age; (b) at least one parent in attendance for all sessions in order to monitor performance across outcome measures; (c) an Internet connection from their home throughout the duration of the study (equipment was available upon parent request); and (d) less than 10 h-per-week of additional 1:1 intervention services.

Nine families contacted the first author either from reading the study description on the center's website or calling to inquire about intervention studies at the center and were enrolled on a first come, first served basis. One family dropped out of the study in the second week of the assessment phase and did not provide an explanation for their termination. The remaining eight families (seven mothers and one father) completed the entire study. They represented married, middle-class, and primarily Caucasian families living throughout the United States (or Canada in the case of one family), all with minimally available

intervention services in their community. Prior to their involvement with the study, parents reported already having internet access in their homes with online usage varying from daily use to less than 30 min-per-week. All research activities were approved by the university's Institutional Review Board and adhered to the Health Insurance Portability and Accountability Act (HIPAA) in response to privacy, security, and electronic transaction guidelines. Parents received verbal and written information pertaining to their rights as study participants, the consent form outlining study procedures, and a Notice of Privacy Practices through the live-streaming, two-way video conferencing and website program used in the study. All parents consented to participate with signed authorization prior to starting the study. Table 1 provides a description of parent–child characteristics at the start of the telehealth intervention program.

Materials and Procedure

Families completed the telehealth intervention sessions from their home using a laptop and web-camera (equipment was available upon request); whereas the therapist accessed the program from an office computer and web-camera. Prior to weekly intervention sessions, the therapist and parent strategized about different locations throughout the house (e.g., family room, kitchen, bedroom) where the laptop could be placed for optimal viewing. This way, the therapist could observe a wide range of parent–child behaviors and interactions without interrupting ongoing activities to have the parent adjust the monitor. Most often, parents placed their laptop in the center of the floor, on a table or chair to capture a wide shot of the room including the kitchen, family room, bedrooms, and backyard. The planned locations and therapist feedback allowed clear visibility and audible communication without requiring parents to solicit another adult to operate the web-camera or to wear a Blue Tooth headset. Parents generally engaged their child with toys (e.g., balls, books, trains), caretaking activities (e.g., feeding, diapering, dressing), and social games (e.g., peek-a-boo, chase) that were a part of their normal routines.

Therapist Training

Parent coaching sessions were delivered to families by the first author and another qualified therapist, both of whom had received extensive training and supervision by one of the model's developers and had piloted the telehealth approach in earlier research prior to conducting the present study. The two therapists followed a set of ethical practice, and privacy guidelines involved with using online forums to deliver intervention (see Trepal et al. 2007 for more information) in addition to following a fidelity protocol on recommended coaching practices for supporting family-centered practice (i.e., collaboration, active listening, self-reflection, contextual and nonjudgmental feedback; Hanft et al. 2004; Rush and Shelden 2005, 2011). These practices were followed to ensure standardization, confidentiality, and appropriate conduct of online interactions with families. The therapists evaluated 75 % of one another's videotaped sessions according to both protocols. Fidelity was 100 % for all checked sessions. Although intervention was delivered to some parents across state lines, licensing was not mandated by our Institutional Review Board (IRB) or

Table 1 Parent-child baseline characteristics

Family ID	Child's CA (months)	Child's ethnicity	ADOS	Parent's education/ employment	Parent's marital status	Parent's income (K)	Parent's internet usage	Additional intervention (hours per week)
2	33	Latino	17	Post-college/full-time	Married	>100	Not daily, 1–2 times per week	1.5^{ST}, $.5^{OT}$
4	22	Caucasian	20	Post-college/full-time	Married	>100	Not daily, 1–2 times per week	2^{ST}, 8^{CAM}
9	34	Caucasian	14	College/full-time	Married	>100	1–2 h	1^{ST}, 1^{OT}, 4^{PET}
11	18	Caucasian	25	College/full-time	Married	50–75	Not daily, 1–2 times per week	None
12	45	Caucasian	14	College/full-time	Married	50–75	1–2 h	1^{OT}
14	21	Caucasian	16	Post-college/full-time	Married	25–49	1–2 h	2^{ST}, 0.5^{OT}
15	27	Hispanic	19	College/none	Married	>100	>5 h	3^{DTT}, 0.5^{ST}, 1^{OT}
16	20	Caucasian	18	Post-college/none	Married	50–75	Not daily, 1–2 times per week	1^{ST}

CAM complementary and alternative medicine, *DTT* discrete trial training, *ST* speech and language therapy, *OT* occupational therapy, *PET* parent education training

hospital practices since all activities fell within the jurisdiction of research rather than standard clinical care. All protocols involving communication and intervention training with families were reviewed and approved by the IRB prior to conducting the study.

Experimental Design and Procedure

A single-subject, multiple-baseline design was conducted across the eight parent–child dyads (Hersen and Barlow 1976). Families were randomly assigned to different predetermined baseline periods ranging between 3 and 8 probes across 2–3 weeks to avoid excessive delays before starting the telehealth intervention. Following baseline, families completed the 12 weekly 1.5 h intervention sessions and three 1.5 h monthly follow-up sessions.

Baseline

Therapists used two video-conferencing twice-per-week to observe and record a 10-min interaction between the parent and child in the activities that typically happened in the family's home. The number of baseline probes per parent–child dyad was selected a priori in order to minimize the amount of time families had to wait before receiving the intervention. Parents were encouraged to engage their child as they would normally do at home whether it involved play, a meal, or a caretaking routine (e.g., washing hands, dressing). There was no instruction or expectation for parents or children to behave in a certain way but rather to share whatever behaviors, activities, and situations parents might want to address during intervention. Generally, parents selected children's highly-preferred toys, familiar social games (e.g., peek-a-boo, chase, tickle, spinning around the room), or specific routines (e.g., feeding, diapering) to demonstrate children's current means of engagement and/or problem areas. These activities set initial parent–child response levels to proximal outcome measures, as well as yielding parent–child goals to target across the intervention portion of the study.

Telehealth Intervention

Telehealth consisted of a live, two-way video conferencing and self-guided website (http://esdmanywhere.org/) delivered on a128-bit encrypted software platform. Parents were assigned individual, non-identifying usernames and passwords for access to the program. The program was developed to facilitate parent-therapist communication (both live-streaming and electronically mediated), to engage parents in delivery and evaluation of the Early Start Denver Model (ESDM; Rogers and Dawson 2010), and to offer additional resources or information that parents could access any time of day and as often as needed.

The ESDM is a developmental, relationship-based intervention grounded in the science of applied behavior analysis for toddler and preschool-aged children with ASD. The parent model, referred hereafter as the P-ESDM (Rogers et al. 2012a), follows the same science of child development and applied behavior analysis; however its content and approach to working with parents focuses on moments of learning inside the daily interactions and activities that make up a young child's life. Its coaching curriculum consists of 10 intervention topics, addressing one new parent skill each week and refining those taught earlier. The 10 topics were: (a) increasing child's attention and motivation; (b) using sensory social routines; (c) promoting dyadic engagement and joint activity routines; (d) enhancing nonverbal communication; (e) building imitation skills; (f) facilitating joint attention; (g) promoting speech development; (h) using antecedent-behavior-consequence relationships ("ABCs of learning"); (i) employing prompting, shaping, and fading techniques; and (j) conducting functional assessments of behavior to develop new interventions.

Parent coaching sessions occurred once-per-week for 1.5 h across 12 weeks. Sessions were scheduled at times of day most convenient for the parent and child to participate together, ranging from early mornings to evenings. Sessions began with the therapist initiating the video call for the parent to answer from their laptop or computer. Once connected, a two-way video screen appeared on each person's computer, allowing the therapist and parent to see, hear, and speak to one another in real time. The therapist asked the parent to relay what events had occurred in the past week in relation to the previously addressed intervention topic. This dialogue was followed by a 10-min period of parent–child interaction within the context of a parent or child-chosen play activity. This interaction served as the data on weekly outcome measures and therefore, coaching or suggestions from the therapist were not given until the activity ended. Following the demonstration, the therapist and parent discussed the parent's experience in relation to the intervention topic, child behaviors, and personal learning goals. With permission, the therapist could also view parents' activity with the website features to look at their usage and progress with the intervention and goals outside of weekly sessions. Hearing from the parent firsthand in addition to viewing their activity with the website helped to identify which intervention strategies and goals went well for the parent and child versus areas of difficulty that might require additional discussion and/or practice.

Next the therapist introduced the new topic through verbal description and review of the website materials. The

parent then practiced the technique in play with the child while the therapist gave feedback on technique use. The parent applied the skill across different activities (e.g., books, feeding, dressing, changing, toy play, social games) and locations in the home (e.g., bedroom, kitchen, back-yard) to facilitate correct and consistent usage. Sessions concluded with the therapist and parent discussing use of the new skill with other caretakers and in other activities and settings at home and in the community.

The website's home page displayed a set of icons (representing interactive tools) for parents and therapists to use together during their weekly sessions in addition to parents using on their own to support their intervention practice. Parents were asked at the start and periodically throughout the study which of the website features they would like to use during sessions with the therapist to assist with their intervention practice. Therapists could also view and track parents' activity across website features at any point, but only did so with parents' permission in addition to always notifying parents (via the website's messaging system) when they did so. Descriptions of each feature follow below (Fig. 1).

Messages

Similar to email, parents could send and receive messages to their therapist or other support members they invited to their account. The anonymous username appeared next to each posting with messages descending in chronological order.

Calendar

Parents could enter their session day and times and other appointments into a calendar, as well enter tasks and set reminders to ensure completion. Information entered remained visible on the right hand side of parents' screen under a header, "upcoming activities". The information was also viewable by clicking on or entering a specific date in the field box.

Photos

Parents could upload personal, family, and/or child pictures to their home page. Parents were not able to see other parents' pictures.

P-ESDM Modules

This featured text and video-based learning modules on each curriculum topic, outlining the strategies with an introduction and rationale of the importance for teaching this particular skill to the child, followed by step-by-step instruction, checklist questions, and video examples of the steps in use with children of different ages and functioning abilities, recorded from prior intervention studies and with

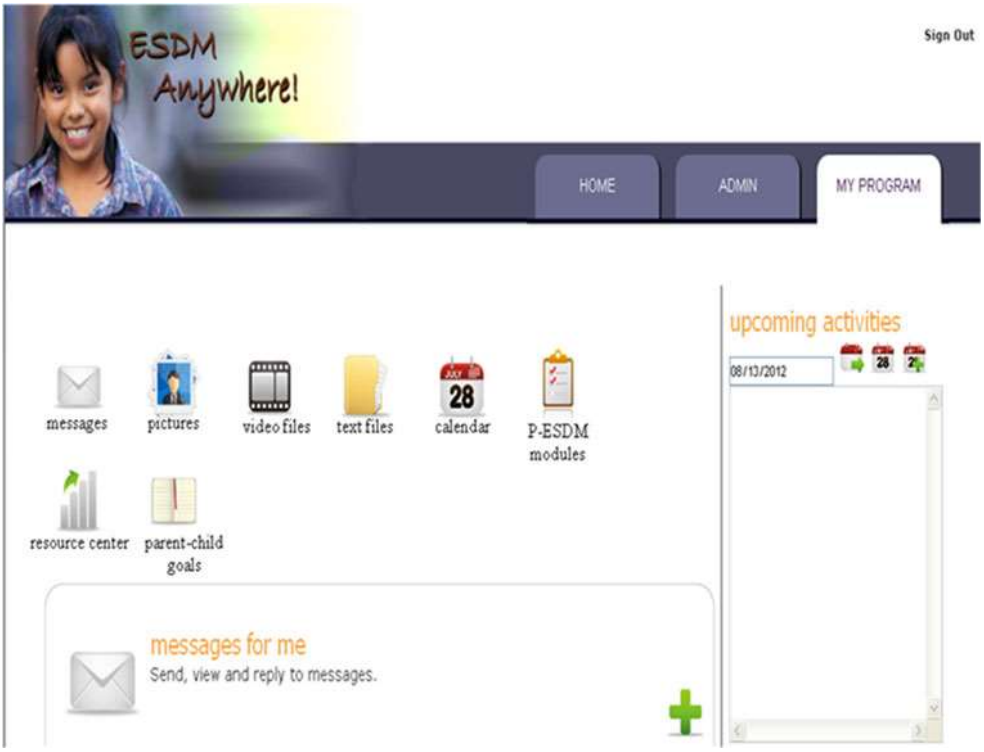

Fig. 1 Screen shot of the esdmanywhere.org home page

parental consent to share footage. Videos of good and poor implementation were shown to contrast the skill differences in technique use and effects on children's behaviors. For this reason, therapists and not parents were selected to interact with children in the videos. It was important that parents felt comfortable learning new skills and not experience added pressure of having less successful interactions viewed by others. Parents that had completed or were currently receiving intervention from our center were invited to have their children participate in the videos. Those parents that volunteered were able to preview all videos before being uploaded to the website. Any video examples that parents felt uncomfortable with were not included in the learning modules.

Parents could view the modules at their own pace, as often as they preferred. Some parents chose to review the modules before each session, in order to practice the techniques beforehand and solicit feedback on specific areas or challenges; whereas other parents preferred having the therapist explain the modules prior to using the techniques. Each module ended with a list of activity ideas for parents to try at home and a section on *frequently asked questions* that had been developed from our ongoing work with the intervention. Parents could follow these suggestions as they practiced using the techniques on their own. Before moving on to the next module, parents were asked to comment and select from a 5-point scale of how relevant and useful each module was related to their learning needs. The therapist was able to view parents' responses in order to provide more information and address specific questions, concerns, or needs during the sessions (Fig. 2).

P-ESDM Tracker

The next website feature allowed parents to monitor how often and where the intervention occurred in their homes (i.e., bedrooms, kitchen, family room, backyard) and in the community (e.g., park, grocery store, church). Parents could then view their entries on a daily, weekly, or monthly basis across all variables. Therapists were also able to view parents' entries and in doing so, could support their practice with feedback and encouragement related to their progress.

Media Sharing

The third website feature allowed parents and therapists to upload and share text, audio, and video files related to the intervention and learning goals. For example, parents could use their phone or tablet to video record an interaction with their child at any time of day and in any setting. The file could then be uploaded to the website and shared with their therapist for further discussion and treatment recommendations. The therapist could also share information, such as treatment goals, additional video examples, and other learning resources, to assist parents in their intervention practice.

Resource Center

Another website feature offered parents information about autism resources organized by categories including education, research, advocacy, early intervention, home issues, family life, and community events. Parents could search for topics by clicking on any of the categories and scrolling through a list of website links and tool kits.

Message Board

The final website feature served as a message board where parents could anonymously post conversational topics, questions, progress updates, or any other information they might want to share with other enrolled families in the study. The first author and research staff also posted material each week to elicit parent discussion, such as latest autism research findings, news releases, and/or other online resources that might be of interest to families. As part of their user account, parents selected non-identifying screen names that would appear next to their post. Parents also had to follow other privacy guidelines when posting material, including not listing parent or child first and last names, contact information, or identifying information about a treatment provider. The first author and research staff previewed all posts prior to official posting on the website. Parents could also report violations at any point by clicking a button, although no violations occurred during the study.

Follow-Up

After the 12 weekly intervention sessions, parents and their children received three 1.5 h monthly sessions to assess the extent of change in parents' P-ESDM skill levels and children's social communicative behaviors. The therapist initiated the video call and after greeting the family, asked parents to engage their child in an activity that represented something they had been practicing since their last session. This might be introducing a new toy or game that previously, the child was unable or uninterested in doing, demonstrating a new skill that the child had recently acquired, or showing how a developed skill had progressed even further. The activity lasted approximately 10 min and no coaching occurred until after the elapsed time. The remainder of the session focused on whichever P-ESDM topics and/or particular learning goals parents selected or seemed important to strengthen based on earlier observations.

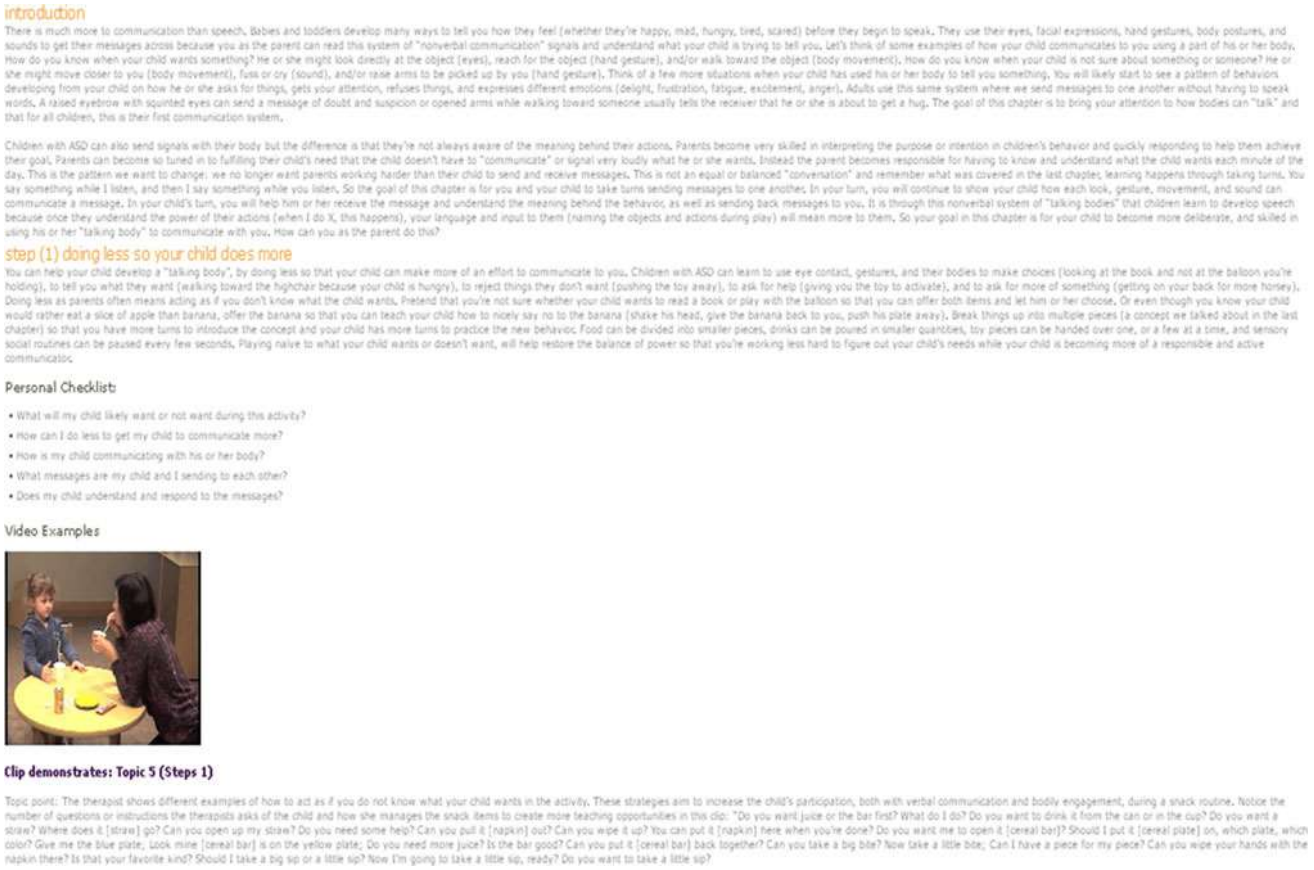

Fig. 2 Screen shot of the esdmanywhere.org P-ESDM module topic

Dependent Measures

The first 10 min of a parent–child activity completed at the start of each video conferencing session was recorded from a software program for later scoring of parent–child behaviors. Session data were reported across the baseline, 12-week intervention, and 3-month follow-up period for each parent–child dyad. Research assistants, one of whom was an undergraduate and the second applying to graduate school, served as primary coders and independently rated and compared 33 % of their observations. They conducted reliability checks with the first author on 15 % of all dependent measures. Each assistant had volunteered at our center and trained to agreement by the first author for more than 1 year prior to their involvement in this study. Reliability training involved careful reading of the measures' operational definitions and reaching inter-rater agreement at 85 % or higher prior to scoring probes. Further, the raters were blind to the study's hypotheses and scored probes in random order to minimize expectations regarding parent and child progress. Four outcome areas were examined as a result of parents using the video conferencing and website program: (1) their satisfaction with the program, (2) their intervention skills and engagement style with the child, (3) their direct usage and impact of the website on intervention and engagement skills, and (4) their effect on improving children's social communicative behaviors.

Parent Satisfaction

Parents completed an eight-item, five-point response scale evaluating their satisfaction with the telehealth intervention at the end of the 12-week period. Items ranging from one (strongly disagree) to three (neutral) to five (strongly agree) reflected parents' perceived usefulness of the video conferencing sessions and website features, their confidence in using the P-ESDM, and whether more information could have been added to the program.

Parent Intervention Skills

The *P-ESDM Fidelity Tool* (Rogers et al. unpublished material, 2012) is a Likert-based 5 point rating system of

13 parent behaviors that define the child-centered, responsive interactive style used in P-ESDM. These behaviors are: (a) management of child attention; (b) quality of behavioral teaching (use of clear antecedent-behavior-consequence events and efficient teaching strategies embedded in the play); (c) adult ability to modulate child affect and arousal; (d) management of unwanted behaviors using positive approaches; (e) quality of dyadic engagement; (f) giving child choices and optimizing child motivation for participation in activity; (g) parent display of positive affect; (h) parent sensitivity and responsivity to child communications; (i) parent use of multiple and varied communicative functions; (j) appropriateness of parent language for child's language level; (k) parent use of flexible joint activity routines with theme and variation in activities; and (l) smooth transitions between activities that maximize child interest and engagement. Scores ranged from one (i.e., no competence) to five (i.e., high competence) with a total score of 80 % or scores of 4 or greater indicating skilled, consistent technique use. The total score was calculated as the mean of item ratings. Inter-rater agreement was defined as raters' scores falling within one point on the Likert scale for each item. The weighted kappa between raters was 0.73.

Parent Engagement Style

Parents' style of interacting to or relating to their child was assessed with the *Maternal Behavior Rating Scale* (MBRS; Mahoney et al. 1986), a five-point Likert rating scale ranging from 1 (very low) to 5 (very high) across the following four categories of : (a) responsiveness and sensitivity to the child's overt and subtle needs; (b) enjoyment and warmth displayed during the interaction; (c) adult-directiveness and teaching pace; and (d) goal-achievement behaviors to target the child's developmental skills. The total score included all subscales except *directiveness* because on this subscale, the median rating, not the highest, reflects the most optimal parenting style. Raters attained reliability by giving the exact rating on a probe-by-probe basis. Intraclass correlations between the two raters had an average of 0.74 across subscales (range 0.62–0.88).

Parent Website Usage

Parents' login and web-page viewing times across tools were tracked throughout the study. Web-page viewing time was calculated by subtracting the difference between the time stamps associated with each click or navigation from one web-page to the next. Time spent refreshing the web-page, logging back into the website, or leaving a web-page open for more than two standard deviations above the mean amount of parents' view time ($M = 6.07$, $SD = 26.56$) were excluded from our analyses.

Child Behaviors

Children's response to parents' use of the intervention was measured through behavioral scoring and parent-reporting. Videotaped probes were transcribed and scored for child production of: (a) functional verbal utterances consisting of single words or approximations (echolalic or unintelligible utterances were excluded) directed toward the adult with body orientation for the purposes of requesting or commenting about an item or action; and (b) nonverbal joint attention initiations involving eye gaze alternation with or without gestures (i.e. giving, showing, or pointing) elicited by the child without any prompting or encouragement from the parent and directed to the parent for the purposes of sharing interest or enjoyment in an activity. Specific categories of joint attention behaviors included the child: (a) looking from the activity to the parent and back to the activity; (b) pointing to an object while activated or being shared between the parent and child; (c) holding up or extending an object to solicit a comment from the parent; and (d) giving an object for the parent to take a turn and complete the same play action as the child. Any joint attention behaviors in response to parent probing (e.g., "show me the doggie," "watch this," or "I don't see the plane, do you?") were not scored since it was the parent and not the child initiating the opportunity. Analyses codes were calculated into frequency of behavior per minute to account for differences in the duration of videotaped probes. The mean-intraclass coefficients for frequency of behaviors between two independent coders blind to the time point was 0.93, with a range of 0.73–0.98.

Parents also completed the questionnaire, *MacArthur Communicative Development Inventories: Words and Gestures* (CDI; Fenson et al. 2007) at the three time points of the study to examine their perceptions of child improvement related to observed change. The CDI is a 396-word vocabulary checklist to capture the expressive words, gestures, and receptive vocabulary demonstrated by the child.

Results

Parent Satisfaction

All parents completed the questionnaire regarding their experience with the telehealth program. Clear trends as reported by the parents in Table 2 suggest that the program

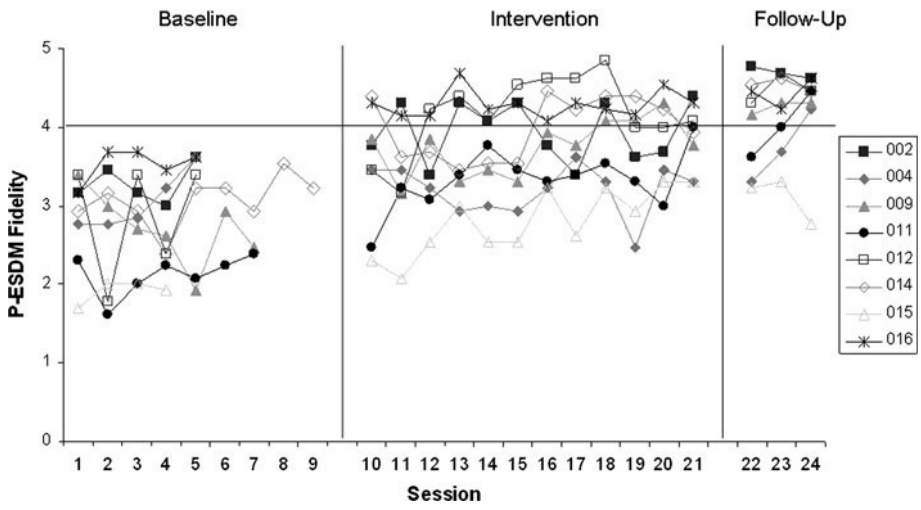

Fig. 3 Parents' fidelity of implementation across conditions

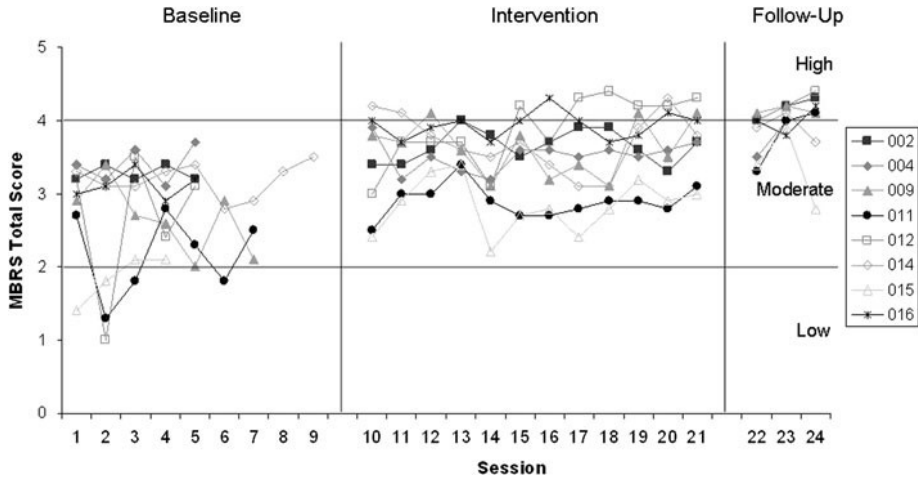

Fig. 4 Parents' total engagement score across conditions

Table 2 Parents' satisfaction with the telehealth intervention program

Theme	% (Number) of strong agreements	% (Number) of agreements	% (Number) of neutral responses	% (Number) of disagreements	% (Number) of strong disagreements
The website was easy to use	62.5 (5)	37.5 (3)	0	0	0
There was enough information on the website to meet my learning needs	62.5 (5)	37.5 (3)	0	0	0
The weekly video conferencing sessions and online video modules were the most helpful aspects of the telehealth intervention	62.5 (5)	25 (2)	12.5 (1)	0	0
I was able to use the telehealth intervention to increase my child's language, play, and social engagement skills	75 (6)	25 (2)	0	0	0
I feel confident teaching other caretakers to use the intervention with my child	50 (4)	37.5 (3)	12.5 (1)	0	0
I felt well-supported by the telehealth intervention and therapist coaching in spite of the distance	100 (8)	0	0	0	0
I would recommend the telehealth intervention parent training to other families	87.5 (7)	12.5 (1)	0	0	0
More information and training could be added to the telehealth intervention	0	0	37.5 (3)	25 (2)	37.5 (3)

was an easy platform to navigate and access the features. All of the parents found the information relevant and useful to their learning needs. The majority of parents felt strongly that the weekly video conferencing sessions and website video modules were the most helpful aspects of the program. They felt very confident in using their intervention skills to improve their child's social communication skills, as well as helping other caretakers do the same. All were in strong agreement about feeling well-supported by the program in spite of not having a therapist physically present and would recommend the approach to other families seeking parent training. When asked whether other information or more tools and training could be added to the program, the families did not feel more resources were necessary.

Parent Intervention Skills

Figure 3 illustrates parents' fidelity ratings across baseline, intervention, and follow-up sessions. Overall, data suggest steady gains in parents' intervention skills from baseline compared to follow-up performance. At baseline, parents' average rating of fidelity was 2.93 (SD = 0.60) with none meeting the criterion of 4.00 or accurate implementation of P-ESDM prior to telehealth coaching or access to the website. During the course of intervention, parents required an average of 7.33 weeks (SD = 4.72) to reach fidelity, as defined by a minimum of two consecutive scores of 4.00 or higher. Their overall mean fidelity during intervention was 3.68 (SD = 0.51) with six of the eight parents achieving scores of 4.00 or higher; whereas the other two parents (i.e., 04 and 15) made improvements but did not meet the threshold. At follow-up, all parents except one (i.e., 15) had at least one fidelity score of 4.00 or higher with a group mean of 4.15 (SD = 0.51).

Parent Engagement Style

Figure 4 illustrates parents' engagement ratings across baseline, intervention,and follow-up sessions. Parents' interaction styles were initially characterized in the low to moderate range on the MBRS total score (M = 2.91, SD = 0.68) during baseline but steadily increased across intervention (M = 3.50, SD = 0.44) with scores ending in the moderate to high range at follow-up (M = 3.87, SD = 0.42). All subscales also followed this pattern of change across the conditions. The *directiveness* subscale, not included in the total score, reflected greater variability with respect to how instructive parents became over time in their interactions with children.

Spearman's rho correlations examined the relationship between parents' intervention and engagement skills across all three conditions as measured with the P-ESDM fidelity system and the MBRS, respectively. The MBRS total and subscale scores were strongly related with the P-ESDM fidelity ratings (see Table 3), suggesting a positive relationship between parents' intervention usage and interaction sty le with children. In contrast, the MBRS *directiveness* subscale referring to parent instructiveness was correlated only with the MBRS *achievement* subscale or parents' tendency to target children's developmental skills.

Parent Website Usage

All parents used the website as indicated in Table 4. After the removal of outliers, parents' average number of logins across the length of the study was 30 (SD = 18, range 9–60) and their average viewing time per day was 18 min (SD = 0:00:25 s, range 0:00:03 s–3 h:24 min:39 s). None of the parents sent messages, used the calendar feature to schedule tasks or appointments, or uploaded pictures to their home page. Parents did access the resource library, message board, and media sharing; however they mostly used the P-ESDM modules and tracker as shown by their average viewing times in Table 4. These were the only features correlated with parents' total time on the website (r = 0.86, $p < .01$; r = 0.76, $p < .05$ respectively). Further, parents' use of the P-ESDM tracker illustrated their

Table 3 Correlations between parent measures

	P-ESDM fidelity	MBRS responsive/ child oriented	MBRS affect/ animation	MBRS achievement	MBRS directiveness	MBRS total score
P-ESDM fidelity	1.00	0.91***	0.94***	0.64**	0.25	0.92***
MBRS responsive/child oriented		1.00	0.93***	0.76***	0.27	0.96***
MBRS affect/animation			1.00	0.74***	0.18	0.97***
MBRS achievement				1.00	0.44*	0.82***
MBRS directiveness					1.00	0.25
MBRS total score						1.00

* <.05, ** <.01, *** <.001

Table 4 Parents' website usage

Parent number	P-ESDM modules[a]	Program engagement[a]	Message board[a]	Media sharing[a]	Resource center[a]	Total time[a]	Average (SD) time[a]
2	1:39:46	0:00:16	1:02:41	0:00:00	0:03:27	2:46:10	0:18:27 (0:33:41)
4	1:12:22	1:49:52	0:29:49	0:00:20	0:00:00	3:32:23	0:16:20 (0:21:27)
9	4:15:58	0:25:26	0:31:22	0:09:22	0:00:38	5:22:46	0:16:59 (0:18:01)
11	5:11:32	3:41:47	0:04:51	0:08:13	0:00:34	9:06:57	0:09:06 (0:11:55)
12	5:15:55	0:47:22	0:01:25	0:00:02	0:00:50	6:05:34	0:16:42 (0:20:24)
14	22:29:00	3:07:20	0:41:53	0:00:38	0:05:12	26:24:03	0:31:40 (0:40:10
15	5:24:40	4:39:42	0:05:09	0:00:41	0:03:30	10:13:42	0:15:27 (0:15:58)
16	6:39:19	0:46:20	0:02:45	0:00:00	0:02:26	7:30:52	0:18:02 (0:23:54)
Average (SD) time[a]	6:31:19 (6:43:16)	1:54:46 (1:43:00)	0:22:29 (0:22:34)	0:03:12 (0:04:20)	0:02:22 (0:1:46)	8:53:04 (7:31:31)	

[a] Time refers to the hours/minutes/seconds

intervention use throughout different locations in their home, including the kitchen, family room, bedrooms, bathrooms, and backyard, as well as out in the community. A series of Spearman's rho correlations were analyzed between parents' total time on the website and individual features with parents' intervention skills and engagement style. Amount of time using the P-ESDM tracker was negatively correlated with the total score on the MBRS ($r = -0.86$, $p < .01$). None of the other tested correlations met significance at the .05 level.

Child Behaviors

Figure 5 demonstrates rates of children's functional verbal utterances and nonverbal joint attention initiations across baseline, intervention, and follow-up sessions. Although the children exhibit notable variability from session to session, there appears to be overall improvement on both measures across conditions. At baseline, children's average rate of vocalizations was 2.97 (SD = 1.83) and rate of joint attention initiations was 1.67 (SD = 1.07). During intervention, vocalizations increased to a rate of 3.60 (SD = 2.51) whereas the rate for joint attention initiations remained at 1.67 (SD = 1.21). At follow-up, group means were 4.14 (SD = 2.04) for vocalizations and 2.16 (SD = 1.34) for joint attention initiations.

Parents' ratings on the CDI were compared across the three time points. Their reporting found increased production and comprehension of words and gestures for all children with an average of 100 more words produced and 90 more words understood from baseline to follow-up (see Fig. 6). Baseline means of vocabulary production and comprehension were 111.87 (SD = 156.03) and 224.37 (SD = 133.25), respectively, compared to intervention averages of 163.88 (SD = 156.03) and 284.88 (SD = 141.53), respectively. At follow-up, the group means increased to 213.88 (SD = 155.08) for vocabulary production and 314.88 (94.16) for comprehension.

Spearman's rho correlations examined the relationship between changes on all child measures and parents' intervention and engagement skills at follow-up. Focusing only on the follow-up data allowed us to examine the impact of parent learning on child behaviors once weekly intervention had been completed. Correlations between rate of children's functional verbal utterances and parents' intervention and engagement skills, as measured by the P-ESDM fidelity and MBRS total score, were significant ($r = 0.89$, $p < .01$, $r = 0.86$, $p < .01$ respectively). There were also significant correlations between children's use of verbal language as reported by parents on the CDI and parents' skill levels in using the intervention and their overall engagement style ($r = 0.71$, $p < .05$; $r = 0.79$, $p < .05$ respectively) (Table 5).

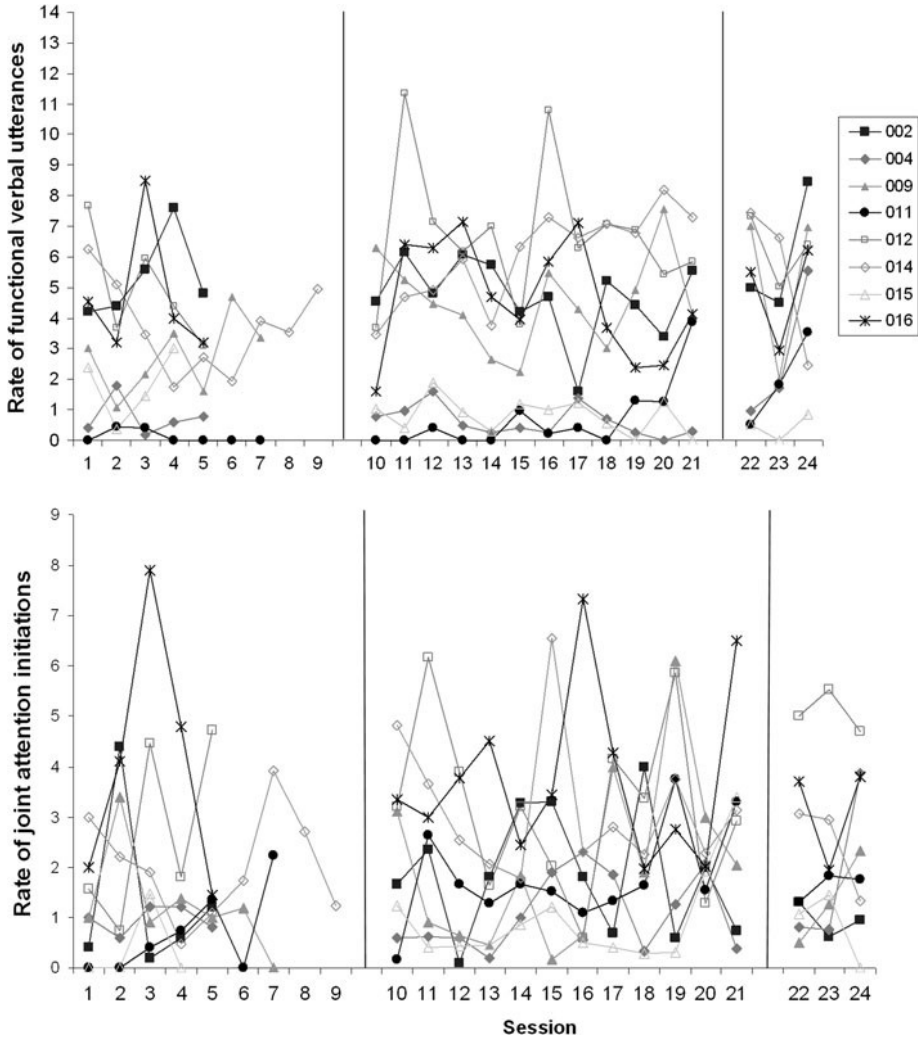

Fig. 5 Child functional verbal utterances and joint attention initiation rates across conditions

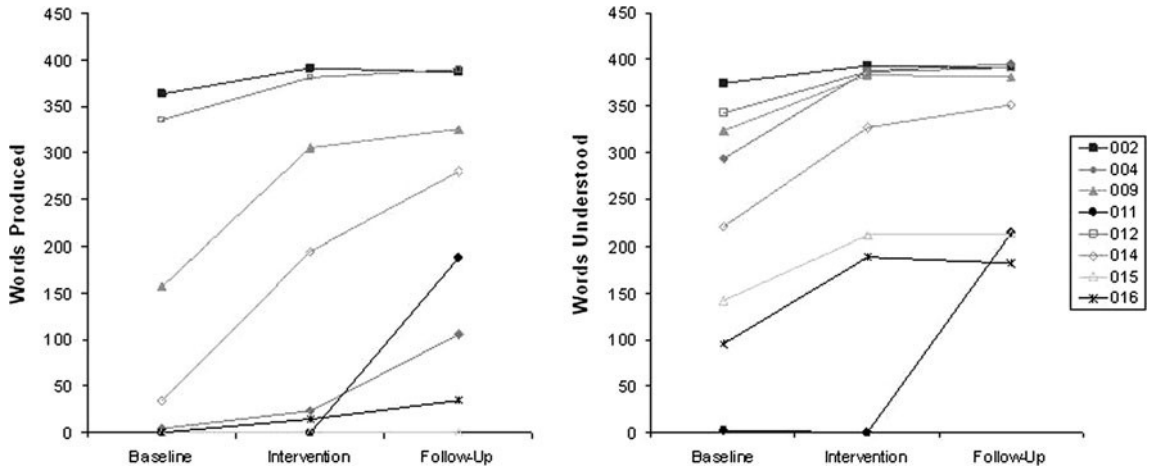

Fig. 6 Parent ratings of child words produced and understood

Table 5 Correlations between parent and child measures

	Child social gestures	Child functional verbal utterances	CDI words produced	CDI words understood
P-ESDM fidelity	0.33	0.88**	0.71*	0.22
MBRS Total score	0.38	0.86**	0.79*	0.54

* <.05, ** <.01

Discussion

The alarming rise in the number of children diagnosed with ASD places major demands on medical, behavioral, educational, and family services worldwide. The current study explored an alternative method of dissemination for providing intervention to families. A telehealth program involving two-way, live video conferencing and a self-guided website was used in families' homes to help parents and children with ASD learn new skills. The first eight families to complete the twelve 1.5 h weekly parent training and three-month follow-up served as pilot data. Each week parents were taught a new skill from the P-ESDM to use with their child inside existing routines, activities, and interactions at home. We examined parents' usage of the telehealth program and whether it assisted in their learning and use of the P-ESDM, as well as whether children's verbal language and joint attention initiations improved from parent implementation.

By the end of the intervention, parents reported having a better understanding and appreciation for helping their child learn new skills at home. Parents felt confident in addressing their child's needs and sharing the information with other caretakers. They described the website as a valuable resource for supporting what they were taught during weekly telehealth sessions; however they rated video conferencing with therapists as highly important for understanding how to use the intervention in their daily life. This finding is consistent with previous literature suggesting that some degree of interaction (e.g., coaching, feedback, problem solving) is necessary to maximize the effectiveness of training programs (Feil et al. 2008; Thomson et al. 2009). The drawback though can be the time and expense involved in providing that expertise. Information on program costs and cost-effectiveness are one of the least frequently reported types of data in autism intervention studies, let alone involving telehealth delivery. This can be unfortunate when program cost is one of the first questions asked by decision makers and is a major barrier to dissemination (Glasgow 2009). While we did not conduct a cost-benefit analyses in the current study anecdotally, our program costs consisted of the software development and technical support for overseeing the website followed by staffing two therapists, each at 25 % of their full salary to work with the enrolled families. These costs, however, may be offset by the amount of time required for parents to effectively learn and use an intervention in addition to saving costs on travel, facility charges, and other indirect resources. Examining the costs of a program as delivered and of replication under different conditions (e.g., telehealth versus in-person parent training) will answer the questions that decision makers usually have about the feasibility of program adoption and the potential for long-term sustainability.

Throughout intervention and follow-up, most parents were able to use P-ESDM and develop learning interactions at home with their child. Intervention usage also related strongly to other parental behaviors thought to support children's development, including responsivity, sensitivity, positive affect, and goal-achievement (Mahoney et al. 1998, 2004; Siller and Sigman 2002). Parents' generally required seven weeks to learn how to use the P-ESDM with their child. This finding supports earlier research that complex intervention strategies can be taught to parents in a short period of time using remote training methods (e.g., Baharav and Reiser 2010; Nefdt et al. 2010). It also compares favorably to the amount of time it took parents attending center-based sessions to successfully learn the P-ESDM (Rogers et al. 2012b; Vismara et al. 2009a). Teaching parents at a distance raises the question of whether modifications (to effectively use the intervention) will be necessary to the original protocol just because the program is delivered in a different format. We cannot answer this question until we better understand the behaviors, learning profiles, setting variables, and other parent–child characteristics associated with successful use of the intervention, itself, followed by the type of staff and delivery conditions associated with successful dissemination. In the meantime, what is encouraging from the research thus far, is the potential for telehealth parent training platforms to retain the essential elements of the original efficacy-tested intervention but to possibly make the information more available, easier to use, and less expensive. Subsequent research in this area will need to continue examining practical questions, such as can a telehealth program work in this setting, how much will it cost, who will benefit the most, and who can successfully deliver the program? Equally important, are answers related to the question of impact on quality of life at the familial, organization, and community level accessing the

intervention and to be aware of negative or unanticipated outcomes as a result of participation. Although no adverse events were reported in the current study, our sample was obviously small and relatively homogenous. Examining quality-of-life measures with a larger and more representative group of families may help to highlight the unintended, negative impact that might occur as a result of a new program and therefore provide useful information for making resource decisions across different content areas.

In the current study, all of the parents engaged with the website. Although their viewing time varied, parents mainly accessed the P-ESDM modules and tracker for gauging their progress compared to the other website features. Parents may have been most motivated to interact with those features directly related to learning about and using the intervention compared to other features that had nothing to do with the P-ESDM (e.g., resource center) or were available through other programs (e.g., calendar, media sharing, pictures). We also observed a decrease in parents' engagement time with the P-ESDM features as their intervention skills strengthened, This was surprising because we thought parents would want to stay connected to some type of support whether it was viewing progress with learning goals, referring back to a learning module, or sharing information with their therapist. Alternatively, parents may have taken what they wanted from the website and without new information offered, they might have become bored or disinterested with the site. Another possibility is that the site and/or features were hard to navigate, such as having to click on several links before accessing the desired outcome or not understanding how a particular tool bar works. These reasons plus the lack of cross-synchronization with other popular platforms (e.g., Google, Facebook) may have deterred parents from further use. Identifying what user variables or incentives will motivate parents to participate, attain competence, and report back on their usage is not clearly understood in parent-implemented studies; yet in order to understand child change, it matters what parents are doing outside of intervention sessions. Understanding how these and other demographic variables (e.g., age, gender, education, income, race and ethnicity, symptom severity, computer experience) interact with telehealth delivery may help us better support families and make distance training programs more effective. We hope to gain more understanding about this topic as we analyze parents' engagement patterns and preferences with our larger sample.

Lastly, we examined how parents' engagement with the telehealth program affected children's verbal communication and joint attention skills. We found that changes in children's functional verbal utterances did relate to parents' intervention use and engagement with higher-quality parenting skills resulting in greater language growth. For children's language to be rated as such, their utterances had to be goal-directed, pragmatically appropriate, and communicated to the parent in meaningfully relevant contexts. Parents certainly reported an increase in their child's ability to use and understand more language at the end compared to the start of the intervention, although we cannot rule out the possibility of biased reporting. However, the telehealth program may have provided parents with the teaching skills to become more aware and responsive to possible learning moments at home and in other settings, thereby exposing their children to more language opportunities.

In contrast, there was less of an effect of the telehealth program on children's joint attention initiations to share experiences with parents. Joint attention represents one of the more affected areas of development in autism (Baldwin 1991; Mundy et al. 1986; Tomasello and Farrar 1986) and developmental growth in this area may require a more focused curriculum to elicit these skills, as evidenced by the work of Kasari et al. (2008, 2010). There is also speculation about how well complex behaviors such as joint attention may be initially supported by abbreviated parent training programs compared to the intensity and expertise of clinician-implemented models (Carter et al. 2011; Green et al. 2010; Oosterling et al. 2010; Rogers et al. 2012b). More research will be necessary to understand the extent to which core areas in children's development can benefit from short-term, low-intensity parent training programs, let alone with technology, compared to being better served with longer, more intense interventions (Kasari et al. 2012).

The limitations of this study cannot be overlooked. The small sample size, potential respondent bias with website usage and child questionnaires, and lack of standardized measures during recorded parent–child interactions make it difficult to know how well the results would generalize to other families. In addition, the use of a multicomponent design (e.g., video conferencing and website features) did not allow for analysis of the individual components without influence from the other pieces. Thus, the effect of these activities without the other components cannot be determined. Further, not all families in the current study benefitted to the same degree. Telehealth may not provide sufficient training for all parents to implement intervention techniques effectively. Some may need the traditional, in-person support and coaching to maximize the effectiveness of the intervention. Others may require more time and practice to achieve fidelity regardless of the delivery modality. Furthermore, the effectiveness of any intervention may relate to how the parent perceives the practices fitting within families' daily routines or their lifestyle. If strategies are perceived as too complex to use on a daily basis, it can become very difficult to reach a high-quality level of competence (Kasari et al. 2008).

Another limitation was in monitoring parents' website engagement given that opened features may not have been in active use. Although we attempted to control for this issue by using a two standard deviation cutoff above parents' average viewing times, we still do not know exactly how parents spent their time on the website. Currently, we have a new application that can detect when website features are in use (e.g., moving mouse, clicking a link, scrolling down the web-page) versus opened but inactive. This may provide a more accurate estimate of how parents use the website and which features maximize learning.

A final limitation involved the equipment necessary to participate in the study. Since all of the enrolled families had a computer or laptop and Internet access, it is unknown how parental participation and learning would differ for families without this equipment and/or the experience using technology. Subsequent research should consider options for telehealth access in public domains, such as universities, libraries, community agencies, hospitals, and schools, and how differences in demographics, current life stressors, and previous training might impact the feasibility, effectiveness and social validity of the program. Further, parents' only login choice to the website was from a computer or laptop. Parents without either option would not be able to access the information, although equipment was available for the purposes of the study. However, the equipment is expensive and not always convenient to use (e.g., parents may not want to wait while the computer or laptop powers up or if neither option is nearby). With technology expanding, the hope is that more options become available and affordable. Currently, we are testing a phone and tablet application (i.e., http://www.esdmtogo) to see whether more accessible options will increase parents' use of the program. Examining how parents engage with multiple platforms and its effect on parent–child learning will help to empirically evaluate the use of telehealth and inform which application systems are cost-effective with families.

This study represents a very early starting point for examining how new technologies can make autism-specific services more readily available without compromising the quality of care delivered to families. Telehealth may be an effective supplement to traditional, in-person parent training, particularly to geographic areas where community services are limited and/or with parents that have demanding work schedules, limited transportation means, or in general cannot commit to extensive intervention programs. Benefits to this approach may include the ease of scheduling sessions with families, the lack of travel expenses, the convenience and flexibility of online learning, and the amount of information that can be observed, stored, and shared electronically. In these circumstances, telehealth may expand resource opportunities, potentially making intervention more accessible, affordable, and easier for families to complete. However, not all families will benefit equally from telehealth intervention. When evaluating effectiveness with this type of platform, it will be critical to assess the breadth of conditions and necessary resources under which a program is successful, the learning characteristics of parents and children related to success, and the process of why the program achieves its effects (or why it did not succeed or was only effective for a subset of participants). Subsequent research with a larger, diverse group of families and stronger methodological approach will determine how viable telehealth may be for providing intervention at minimal cost.

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