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Developing an empirically-based adaptation an training model for intervention scale up of classroom pivotal response teaching: A protocol paper

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ABSTRACT

While there are multiple evidence-based practices (EBPs) available for students with autism, ongoing barriers to use in schools include limited access to training for educators and substantial provider modifications that limit fidelity. This suggests a need for further research to support data-informed adaptations and innovative methods for training and coaching teachers. In response to this need, the objectives of this protocol paper are to (1) describe the development of a data-informed adaptation process for an EBP, and (2) compare the effectiveness of two methods (online virtual and a combination of in-person and online virtual) for training teachers to use the adapted EBP. Outcome measures will include teacher implementation and sustainment of the EBP, teacher/coach relationship, and student outcomes.

1. Introduction

1.1. Background and significance

Of the multiple evidence-based practices (EBPs) available for students with autism, many are composed of several strategies or components (e.g. Perepletchikova et al., 2007; Steinbrenner et al., 2020). However, school-based providers' use of EBPs has been limited and teachers report choosing specific components to fit their students and setting, rather than implementing the package as a whole (Stahmer et al., 2005, 2012). Across studies, data indicate educators demonstrate low to moderate fidelity (Pellecchia et al., 2015; Sam et al., 2021) and make extreme adaptations to EBPs in community settings (Rogers, 2003; Stahmer et al., 2005; Suhrheinrich et al., 2013). In addition, when intervention fidelity is measured, researchers typically use a composite score (Mandell et al., 2013). This limits characterization of teacher adherence to intervention protocol and component-based analysis of fidelity, which is necessary to identify whether individual components differentially impact child progress. Early research suggests that teachers' differential fidelity to specific components of a comprehensive EBP is related to student outcomes (Pellecchia et al., 2015; Stahmer et al., 2019). This indicates a need to better understand which components lead to positive outcomes to inform optimal teacher training.

1.1.1. Adopting a common elements approach for autism

A "common elements" approach in identifying the key components of interventions may increase effective implementation (Weisz, 2012). Data indicate that children's developmental outcomes are linked to the use of key elements of EBPs (Garland et al., 2014). Therefore, identifying key components, rather than focusing exclusively on full protocols, may simplify training and increase teachers' ability to effectively implement interventions (Embry & Biglan, 2008). Chorpita, Daleiden, and Weisz (2005) proposed a distillation and matching model in which interventions are conceptualized as composites of individual strategies. This model allows empirical matching of specific strategies to students, settings and other factors to individualize interventions and has been successfully adapted for practice in children's mental health (Weisz, 2012). Thus, identification and application of key components may support integration of EBP for autism in school programs.

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While there is limited empirical research examining the link between specific intervention components and child outcomes, one method of examining key components is to measure teachers' fidelity to specific intervention components that are the proposed mechanisms of change. Abry and colleagues (2015) demonstrated that variability in providers' use of specific components of a social-emotional learning intervention were linked to child outcomes and could be used to identify the key ingredients (Abry et al., 2015; Gulsrud et al., 2016; Sanetti & Kratochwill, 2009; Schulte et al., 2009). Examining the impact and teacher use of individual components will help determine if the EBP is being implemented in a manner that is likely to be both effective and maximally efficient. Given the heterogeneous needs of students with autism, it is possible that different components of packaged EBPs may be more or less influential for certain students, and may vary by learning goal (Jobin, 2012; Rieth et al., 2014, 2015). Therefore, a component-based approach to examining fidelity will also provide information about the impact of teacher-initiated adaptation and individualization of interventions based on the needs of each specific student with autism. Identification of EBP key components is a critical step toward training in common treatment elements and successful scaling up of evidence-based programming for autism across schools nationwide.

1.2. Classroom pivotal response teaching (CPRT)

Classroom Pivotal Response Teaching (CPRT) is an example of one such multi-component EBP. It was collaboratively adapted by researchers and educators . The original model, Pivotal Response Training (PRT), which has been consistently identified as an EBP in multiple systematic reviews (National standards project, 2015; Steinbrenner et al., 2020; Wong et al., 2015). Numerous research studies have demonstrated PRT's effectiveness in improving communication and social skills (Gengoux et al., 2019; Humphries, 2003; Koegel et al., 1997; Koegel, 1992; Laski et al., 1988; Schreibman et al., 1991; Sze et al., 2003) as well as reducing inappropriate and disruptive behaviors (Koegel, 1999; Mohammadzaheri et al., 2015). Despite its strong evidence-base, very little research has examined the use of PRT in the context of school systems (Stahmer et al., 2005). The limited available evidence of how teachers implement PRT indicated significant amounts of modification (Stahmer et al., 2005) and low fidelity (Suhrheinrich et al., 2007). Therefore, CPRT was developed (Stahmer et al., 2012; Suhrheinrich et al., 2013) based on teacher-informed adaptations to the original model that were tested to examine their effects on student outcomes (Reed et al., 2013; Rieth et al., 2014). A randomized controlled efficacy trial took place in 17 school districts across San Diego County with a total of 127 teachers and 294 students with autism (Suhrheinrich et al., 2020) .

1.2.1. Teachers' sustainment and adaptation of cprt

Multilevel models indicated significantly higher fidelity of CPRT (coded by naïve observers) after training as compared to control. The majority of teachers (73%) met trainer-coded CPRT fidelity after an average of 7.6 coaching sessions. Based on a sustainment survey issued 18 months post-training, 95% of teachers report still using CPRT and 73% report using CPRT with new students. Teacher's overall attitudes toward CPRT were also measured with the Evidence-based Practice Attitudes Scale (EBPAS; Aarons, 2004). Positive attitudes towards CPRT were associated with a higher percentage of coaching session protocol completion (an important indicator of engagement). These positive attitude scores, based on the EBPAS, were also related to trainer-rated teacher willingness to accept feedback and to more sustained use of CPRT over time (Suhrheinrich et al., 2020).

Despite these positive implementation outcomes, however, teachers reported significant modifications/adaptation of CPRT over time. In monthly surveys after training, teachers indicated they 'usually' used 63% of CPRT components with an average of 24% of CPRT components reported as 'Never or Rarely' used. These self-report data are supported by trainer-rated fidelity scores from the follow-up year, in which teachers' range of percent of components with a passing fidelity score varied from 31% to 100%. While roughly 25% of teachers were still implementing at least 80% of the CPRT components, 25% were implementing less than 50% of the intervention, indicating they may be picking and choosing pieces to sustain. Therefore, examining the effect of individual components of CPRT and its effect on child outcomes may be integral.

1.2.2. Preliminary component analysis of key PRT components

While data on the effect of individual CPRT components are not available, retrospective video examination of providers-use of the original PRT protocol found clear associations between individual components and within session child behavior and skills (Stahmer et al., 2019). The examination also looked at combinations of components and how they related to child behavior. This component analysis of PRT suggests a need for relatively intensive use of most components to maximize positive child response. That is, use of the majority of components at high frequencies was associated with increased child engagement, responsiveness, communication, and correct responding. Given the clear data that even after collaborative intervention modifications, teachers continue to independently modify CPRT by using only some of the prescribed components and by implementing CPRT with differing levels of fidelity, there is a strong need for data-based guidelines for adaptation as teachers may benefit from data-based guidance on how to adjust their use of the components of CPRT for individual students.

1.2.3. Ongoing virtual professional development (OVPD): a promising alternative for scaling up EBP training

In addition to providing guidance on how teachers can simplify use of EBP, another important feature that will help scale up EBP use is to make training more accessible. In archival CPRT projects, the training package included both a full day workshop and ongoing classroom coaching offered locally and in person. While effective at improving and maintaining teacher fidelity and confidence in their ability to use an intervention (Burns, 2011; Cornett & Knight, 2008; Suhrheinrich, 2011) the local, in-person modality is not feasible on a broader scale.

Virtual PD, therefore, may be key to broader scale-up given its ability to increase access to information for a greater number of people. Recent developments in technology now include simulated environments which offer interactive learning of both content and technical skills and discussion groups and networking opportunities for teachers (e.g., Wong et al., 2015) in a way that is both immersive and synchronous. In addition, early studies suggest that facilitated and interactive web-based training programs may represent the best of both worlds: the flexibility and access to content on the internet alongside the involvement of a specific coach who can respond individually to trainees' needs (Ho & Burns, 2010; Means et al., 2009). A systematic review of the literature on the use of virtual training for autism interventions also suggest that Virtual PD and its associated advantages (e.g., reduced cost, increased access) may be a viable approach to scale-up and can increase successful use of EBPs (Hooreman et al., 2008; Storie et al., 2017; Wainer & Ingersoll, 2013). Additionally, low-resource tools with broad potential for scale up have not been developed and comparative advantages of online, in-person, and hybrid approaches (some combination of online and in-person) are not clear. Therefore, in order for CPRT implementation to be scaled up, training materials need to be modified and be made available in an interactive, web-based format as well as include virtual coaching.

1.3. Summary

Given the need for data-based support to adapt EBP for autism and CPRT specifically, an important next step is component analysis. Outcomes of the analysis can further inform how providers tailor CPRT to best support student needs and contextual factors. Additionally, the existing literature indicates a need for evaluation of innovative approaches to professional development, such as on-going virtual training and coaching. The current study will address both of the research aims.

2. Research plan

The proposed methods include two phases. Phase One is focused on development, including component analysis and development of adaptation tools and training materials. Phase Two involves an experimental evaluation of the tools and resources. The methods for each phase are presented below.

2.1. Phase one: development process

The first phase focuses on two research questions that will establish guidelines on how individual CPRT components affect student outcomes.

Which individual CPRT components or combinations of components have the greatest impact on student outcomes?

What is the relationship between fidelity of CPRT components and student characteristics, educational goals and teaching activity?

Phase One also has two development activities focused on-line tools for teachers and paraprofessionals.

Development of an interactive decision tree to inform the adaptation of CPRT for individual students, goals and activities based on the data from the component analysis .

Development of an interactive on-line training and distance coaching model for teachers and paraprofessionals.

2.1.1. Sample of archival data

The data sample includes approximately 2068 videos of classroom activities collected during a prior effectiveness trial of CPRT in schools. The data sample included 147 teachers and 294 students with autism (ages 3–11). See Suhrheinrich and colleagues (2020) for a complete description of the effectiveness trial methods, all data coding procedures, participant demographics and implementation outcomes.

2.1.2. Measures included from archival data set

The following measures were collected at the beginning and end of each year during the previously completed effectiveness trial of CPRT. Standard scores for each will be used in the analyses.

Pervasive Developmental Disorder-Behavior Inventory (PDDBI; Cohen, 2003). The PDDBI is a questionnaire designed to detect changes in behavior or intervention responsiveness and assess behaviors associated with autism across categories such as, approach/withdrawal problems and receptive/expressive social communication abilities. It can be used with children 1.6 to 12.5 years old. Previous studies using the PDDBI have reported good reliability with an alpha coefficient of 0.93 (Cohen et al., 2003, 2010; Cohen & Sudhalter, 2005).

Goal Attainment Scaling (Kiresuk & Sherman, 1968; Ruble et al., 2012; Ruble et al., 2010). The GAS form provides a scalable assessment of IEP goals to allow comparison across goals, students, and classrooms. During intake, each student's IEP goals will be reviewed, and a GAS template monitoring form will be used to develop objective, specific behavioral descriptors delineating observable estimates of degrees of progress toward the IEP objective (Ruble et al., 2010). A 5-point scale will be used to determine progress. Teachers will describe goal progress and provide data to independent interviewers who will assign ratings. GAS scores will be used to examine progress over time for academic, social, behavior, and communication IEP goals. Intraclass correlation for GAS scores have been reported as high (r=0.99) (Ruble et al., 2012).

Mullen Scales of Early Learning (MSEL; Mullen, 1995) or *Differential Abilities Scales-II* (DAS-II; Elliot, 2012). The MSEL is a developmental assessment designed for children from birth to 68 months. It is composed of five subscales: gross and fine motor, expressive and receptive language, and visual reception. An overall standard score, the Early Learning Composite (ELC) can be calculated (M=100, SD=15) from four of the scales: fine motor, expressive and receptive language and visual reception. Test-retest reliability ranges between 0.83-0.98 and interscorer reliability is 0.99. Construct, concurrent, and criterion validity are good (Bishop et al., 2011).

The DAS-II is a developmental assessment designed for children from 30 months to 17 years and 11 months. The DAS-II provides an overall General Conceptual Ability Score (GCA) which is a composite of reasoning and conceptual abilities (M=100, SD=15). Inter-examiner reliability coefficients range from .90 to .94. Test- retest median stability coefficients of .90 to .95 for GCA Score (Sattler, 2001). Convergent reliability between the MSEL and DAS was found to be good in children with and without children with ASD (Bishop et al., 2011). The DAS-II will be used to assess all children unless baseline scores cannot be obtained on all subtests. In those cases, the MSEL will be conducted instead. These assessments and the hierarchy of use are recommended by the Autism RUPP network (Arnold et al., 2000).

Autism Diagnostic Observation Scale, 2nd Ed (ADOS-2; Lord et al., 2012). The ADOS-2 is a semi-structured, play-based assessment used to evaluate the presence of autism symptomatology. There are four modules: Toddler module for children ages 12-30 months without phrase speech; Module one for children ages 31 months and older without phrase speech; Module two for children with phrase speech; Module three for children and young adolescents with fluent language; and Module 4 for older adolescents and adults with fluent language. The appropriate module for each student will be determined and given by the examiner during intake and a severity score and classification will be used to characterize the sample. Interrater reliability of ADOS-2 classification is high: 95% for Module 1, 98% for Module 2, 92% for Module 3 (Lord et al., 2012).

2.1.3. Statistical analysis of archival data

Given the nested nature of the data, hierarchical linear modeling (HLM; Raudenbush & Bryk, 2002) will be used as the primary statistical model. All data analytic strategies will follow the recommendations of Brown et al. (2008) and the Prevention Science and Methodology Group for randomized field trials. Preliminary data screening and cleaning will require examination of the data distributions for normality and missing data patterns at both the univariate and multivariate level. To determine the relationships between FI of CPRT components and (a) student proximal outcomes and (b) student distal outcomes, the model will include: (a) video units [level-1] nested within students [level-2] nested within teachers [level-3]. Possible clustering effects will initially be estimated by examining intraclass correlation coefficients to determine if the clustering is necessary for each higher-level of the nested data structure.

To identify individual CPRT components or combinations of components that have the greatest impact on student outcomes, student proximal and distal measures will serve as level-1 outcome variables and component fidelity will serve as level-1 predictor variables. To evaluate relationships between fidelity of CPRT components and student characteristics, educational goals and teaching activity, component fidelity will serve as level-1 outcome variables, child characteristics will serve as a level-2 predictor variable, and goal and activity type will be examined as level-3 predictor variables.

To determine if certain combinations of components will best relate to positive student behavior and outcomes, a latent profile analysis (LPA) will be used to group teachers into different profiles based on the frequency with which they used particular CPRT components. The determination of the number of profiles that optimally fits the data will be based on multiple fit indices and statistical tests; these will include the Akaike Information Criterion, the sample-size adjusted Bayesian Information Criterion (sBIC), the Vuong-Lo-Mendell-Rubin adjusted Likelihood Ratio Test, and the Bootstrap Likelihood Ratio Test. Additionally, the entropy index, an aggregate index of posterior probabilities that reflects the overall precision with which subjects were correctly classified (Berlin et al., 2014; Roesch et al., 2010) will be consulted. Once group membership is established, the profiles will be further examined using

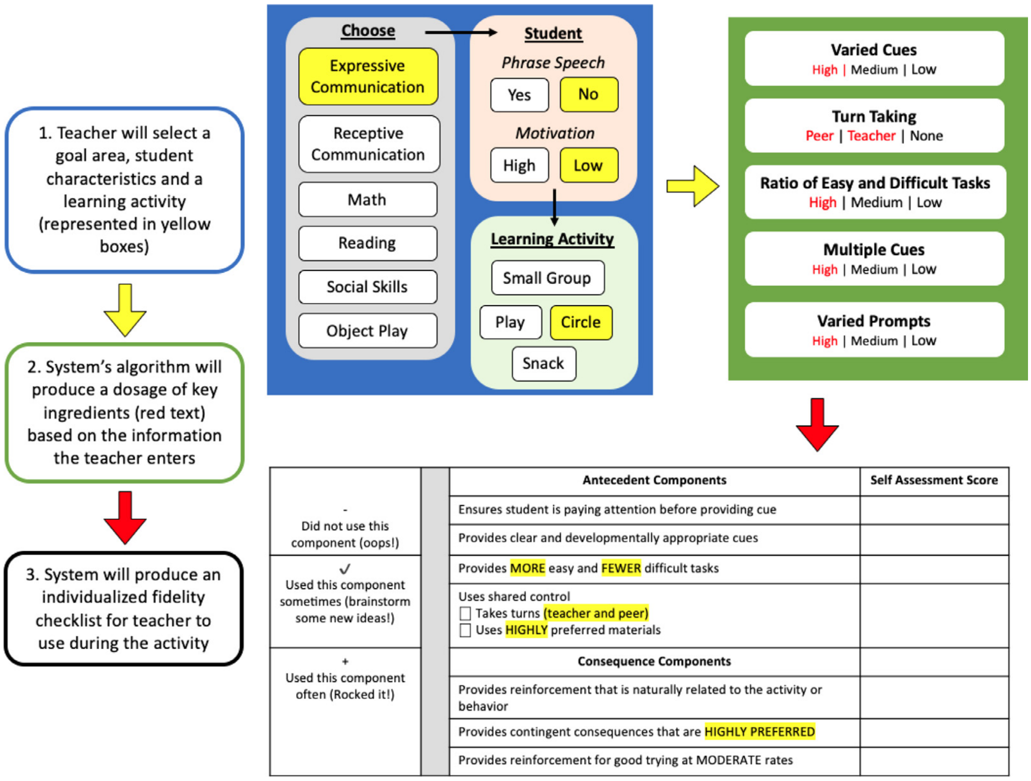

Fig. 1. Graphical model of the CPRT Decision Tree.

multilevel regression models to determine whether group membership relates to child behavior and outcomes. For this analysis, child behavior will serve as a level-1 outcome variable and group membership will serve as a level-1 predictor variable.

Power analyses were conducted to determine if the proposed sample sizes at each level of the nested data structure were adequate given the research aims. To calculate the variance inflation factor (VIF) associated with this 3-level design, recent recommendations for ICC values (ICC=.10; WWC Procedures and Standards Handbook 3.0) and an average number of (a) 6.5 video units per child and (b) 3.03 students per provider were used. These values resulted in VIF values of 1.55 at the child level and 1.20 at the teacher level. In addition, a medium effect size ($R2 = .06$) and an alpha level of .05 were specified. The multiple regression procedure from the PASS program was used to formally conduct the power analyses (Hintze, 2008). Based on the target specifications, these analyses are 80% powered to find an effect size of this magnitude with 280 video units nested within 43 children nested within 14 teachers. These projected sample sizes are well below the existing sample size of 2068 video units nested within 294 students nested within 147 teachers .

2.1.4. Development of a CPRT decision tree

The decision tree will identify CPRT components to use based on characteristics of the student as well as selected goals and teaching activities. Based on the findings from the component analysis, the CPRT components associated with best outcomes for the characteristics of interest will be used to inform the decision tree (see Fig. 1). To generate these recommendations, teachers will input the characteristics into an interactive tool that will generate a list of appropriate components, a fidelity checklist based on the identified components, and an individualized data sheet linked to the student goals.

The development of the decision points and web-based interface will be completed through an iterative process in partnership with an advisory board of special educators to ensure relevance and feasibility of use for the final product. First, results of the component analysis will be presented. The advisory board will prioritize decision items based on significant findings related to individual CPRT components and provide feedback on factors that enhance user experience. Each advisory board member will apply the decision tree tool to their own lesson planning and preparation across at least three students and instructional activities and provide feedback to inform the finalized product.

Although the decision tree will be limited in scope and will not account for all factors that may influence the effect of specific CPRT components on student outcomes, the identified factors (student characteristics, targeted learning goal, and activity type) reflect information teachers can readily access and regularly integrate into lesson planning decision-making. The purpose of the decision tree, therefore, is to streamline the process of making these decisions based on empirical evidence.

The decision tree will be adapted through an iterative process. Once the first draft is developed in collaboration with our advisory board, the CPRT Decision Tree will be externally reviewed by 10 researchers and 10 teachers who have used CPRT extensively. They will use the CPRT Decision Tree and generate a fidelity instrument and data collection sheets in their own work for one month and then provide feedback. Structured feedback on usability and feasibility will be solicited and incorporated into revisions.

An external review of the revised CPRT Decision Tree and procedures will then be solicited from an additional group of teachers familiar with CPRT. CPRT Decision Tree procedures and corresponding tools will be distributed to 15 teachers who work with students with autism and have been trained in CPRT. They will use the CPRT Decision Tree procedures and fidelity instrument in their classroom. They will provide feedback about feasibility and usability and opinions will be considered for additional modifications to the tool.

2.1.5. Development of an interactive web-based training program

CPRT training materials will be adapted to emphasize key components and their relationships with student outcomes, as well as the use of the decision tree to individualize CPRT for classroom use. Adult learning strategies and best practice for virtual professional development and coaching will be incorporated into the training program. We will iteratively pilot test portions of the program for usability and make adjustments based on user feedback.

Existing didactic training protocols will be adapted to highlight the use of the CPRT decision tree . A similar progression of content to previous trainings will be followed. Training will include active, systematic, direct and explicit instructional methods (e.g., step-wise training of ABA then specific CPRT antecedent and consequence strategies; interactive, structured performance-based feedback on skill- building; practice with feedback; sustained training efforts) associated with improved provider competence and student outcomes (Beidas & Kendall, 2010; Miller et al., 2004; Odom, 2009; Scheuermann et al., 2003; Sholomskas et al., 2005). The CPRT manual , decision tree and accompanying materials will serve as the curriculum.

Innovative Immersive Practice: The Frank Porter Graham Child Development Institute (FPG) Instructional Design team will develop an immersive environment that will simulate working with a student with autism using CPRT. Modules will include simulated narrative scenarios, a repertoire of behaviors for students and specific choices of speech and actions, and a decision tree algorithm. This design will allow learners to practice developing a lesson plan, reviewing student preferences, choosing a goal and activity, inputting student characteristics into the decision tree tool and simulating the use of strategies on a virtual student (Wang, 2014; Xu et al., 2014).

To fully engage learners, the modules will intermix animated didactic instruction (for introduction, definition, and description of concepts) with hands-on interactive exercises (for exploration of, practice with, and application of learned concepts). This balanced instructional design is intended to maximize learning and retention. In addition to incorporating foundational instructional design elements such as Gagne's nine events (Gagne et al., 2005), Kemp's cognitive learning design model (Kemp & Dayton, 1985) and Bloom's (revised) taxonomy (Anderson et al., 2001; Bloom, 1956), the module design will also incorporate instructional design industry best practices of interactivity, gamification, and narration/storytelling. These practices are inter-related and part of the realistic, narrative scenarios employed. By engaging in virtual scenarios, the user experiences a series of brief videos with voiceover, motion graphics, and dynamic feedback designed to meet each learner's need (Sanders & Udoka, 2010; Wang, 2014; Xu et al., 2014). Even more importantly, utilization of the API protocol allows full customization of the data collected. Each learner choice and interaction will be recorded and operationalized into conceptually meaningful variables, aligned with instructional design strategy. These variables will then be correlated with outcomes to assess the effectiveness of not only each module but also each interaction within each module. Furthermore, this learning ecosystem also allows data to be queried into custom PDFs housed within the module, enhancing the instructional design strategy. Learners will leave each module with (or digitally save) a custom summary conveying their individual progress, and the areas they may need to improve. Instructors can access all customized learner data by accessing the database directly, before onsite instruction.

Examples of interactives include (a) virtual simulations (dynamic scenes in which the user selects options to solve a simulated problem and receives personalized feedback); (b) branching role plays (video clips of different resolutions for a scenario are displayed based on user choices); (c) self-assessments (Q&A simulations, knowledge mini-quizzes, self-report questionnaires) with personalized report and recommendations; and (d) visualization wizards in which educators define needed steps to reach a goal and choices are dynamically displayed. For example, choices related to student preferred materials, development of sample lesson plans and practice using data sheets to track student progress will be provided.

2.2. Phase two: CPRT distance training pilot study

The second phase of the proposed work will be a pilot study examining the effectiveness of the CPRT Ongoing Virtual Professional Development Program in teachers and paraprofessionals serving children with a primary educational category of autism in preschool through fifth grade. A small randomized trial will examine:

1. Improvement in CPRT fidelity,
2. Improvements in student IEP goals and behaviors;
3. Whether IPT or OVPD facilitates learning, training engagement and implementation in conjunction with the web-based tools and distance coaching;
4. Any remaining barriers to CPRT distance training.

2.2.1. Pilot study hypotheses

1. Across both groups (IPT and OVPD), teachers and paraprofessionals will demonstrate fidelity of CPRT key ingredients based on fidelity measured as linked to the decision tree for each educator/student dyad. This will be measured based on objective coding of CPRT.
2. Based on the promotion of trainer-trainee alliance through in-person contact, educators participating in IPT will have fewer missed coaching sessions, report greater usage of CPRT in the classroom and have higher ratings of coach-teacher alliance than the OVPD participants.
3. Educators participating in OVPD will have greater use of on-line resources, including on-line community activities and immersive virtual practice, and thus will demonstrate increased CPRT knowledge over the IPT participants.
4. Students enrolled in classrooms with teachers with high fidelity of CPRT and who report high usage will have greater outcomes (IEP goal progress; Behavior) compared with students enrolled in classrooms where teachers do not have high fidelity of CPRT or high usage.

2.2.2. Participants

Educators. Participants will be recruited through public school districts in California and Illinois. Participants will include teachers ($n = 20$) with at least one student with a primary educational diagnosis of autism, and no prior training in CPRT. All paraprofessionals in participating teachers' classrooms will be invited to participate. Given the variability in number of paraprofessionals per classroom, we anticipate 20–40 paraprofessionals will participate in the study.

Students. Student participants ($n = 20$) with a primary educational classification of autism will be recruited through participating teachers.

2.2.3. Procedures

Classrooms will be randomized to one of two training models: In Person Didactic Training (IPT), or Ongoing Virtual Professional Development (OVPD) with 10 classrooms assigned to each group. Both groups will receive access to the immersive practice tool, the online CPRT community, and distance coaching. Both groups will complete intake assessments by telephone, on-line or using paper and pencil measures. Each educator will receive the assigned training, which will begin in the Fall and conclude at the end of the school year (post training measures). A final coaching and measurement session will be conducted the following Fall (follow up measures).

2.2.4. Video collection and reliability of data coding

Each educator will be video recorded during two classroom activities at the beginning and end of the school year. Educators will select two activities at intake (e.g., circle time, center rotations, language arts) which will be kept consistent throughout the study. While educators may initially alter their performance during recording, providers in the previous study quickly grew accustomed to the cameras and interacted with students in a natural manner.

Digital, password-protected files will be uploaded and stored on a secure, designated server for back-up via Zoom using the Sibme Software. Consent for participation in the study will include explicit consent for videorecording. All coaching sessions will be recorded to examine fidelity of coaching procedures.

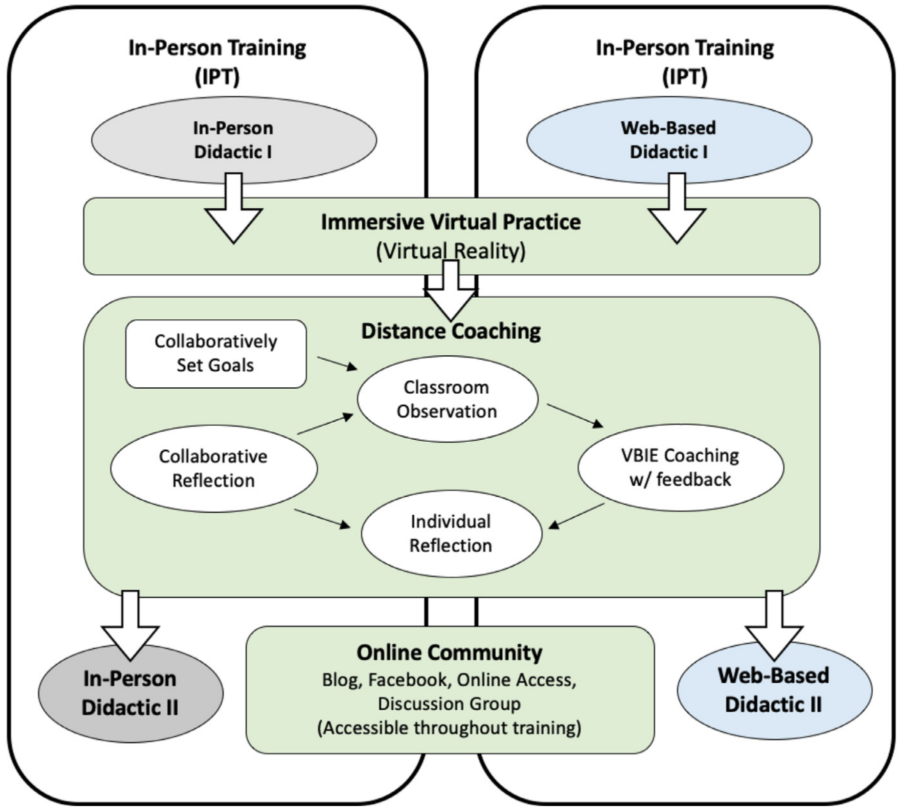

Fig. 2. Graphical Model of Teacher Training.

To ensure the integrity of video measures, coders naive to the study hypotheses will be trained to code CPRT fidelity. They will meet reliability standards of 80% correct across two videos and two activities before independently coding. Reliability will be checked every month by the investigators and if there is less than 80% agreement between the investigator and the coder, additional training will be provided until agreement is achieved. Thirty-three percent of all videos will be scored by a second person.

2.2.5. *CPRT training and coaching*

After intake assessments (see Measures), training in CPRT will begin. Training and coaching will be conducted by a trainer with extensive CPRT experience. Approximately eight hours of didactic training (see below for delivery method) will be provided and will include lectures, video examples, case illustrations, lesson planning, and data collection with feedback and discussion. The specific topics covered are: 1) Learning Your ABCs – An introduction to behavioral principles as the foundation for CPRT, 2) The Components of CPRT, 3) Using CPRT with Groups of Students, 4) Individualizing CPRT to Target Individual Student Goals in Specific Activities, 5) Integrating CPRT into Your Classroom, 6) Data Collection, 7) Maintaining Fidelity of CPRT. Additionally, all teacher participants will be given the CPRT manual and newly developed decision tree technology prior to didactic training.

Training will be conducted either in person (IPT) or via the internet (OVPD) depending upon group assignment (Fig. 2). (1) IPT will include an initial one-day training covering topics 1–4 above, interactive activities such as lesson planning and identifying motivating materials, and an on-site structured classroom observation. A second visit will occur 2 months after the first visit and will cover topics 5–7. In person training will be conducted with groups of 3–8 teachers in a given district/region. All online content (see below) will be available to the IPT group for use at their discretion. (2) OVPD will include content delivered in an interactive online platform (see below) and web-based meetings conducted via Zoom to discuss the topics and complete the interactive activities such as lesson planning. Educators will be asked to move through the content within a given period of time prior to each meeting (online and facilitated session length will be synchronized with the IPT training time). Four web-based meetings to support learning of the first four topics are anticipated, however, the finalized OVPD protocol will be developed in partnership with the advisory board. Zoom meetings will be conducted with groups of five teachers in a region. A second set of lessons on topics 5–7 will become available two months after the first visit and educators will participate in Zoom meetings.

All participants will have access to immersive practice and web-based tools and will receive coaching through virtual technology as these aspects are crucial to potential scale-up. However, to inform the comparative efficiency and effectiveness of blended versus exclusively web-based training, two models of initial didactic training in combination with the other tools will be compared (Fig. 2). After didactic training is complete, educators in both groups will be asked to complete at least three virtual immersive practice sessions prior to coaching. A follow up coaching session will occur early in the next school year to help with sustainment of practices.

Fidelity of Implementation of Training. Materials in each condition will be identical and coaches will be trained to present the materials (for IPT) and conduct the activities consistently across groups. All training and coaching activity, classroom visits and coaching sessions will be self-coded using fidelity of implementation checklists, and 20% of sessions (presentations, activities, visits, coaching) will be coded by one of the investigators.

2.2.6. *Measures*

Measures were chosen to balance the competing goals of carefully characterizing constructs of interest while minimizing the number of instruments to reduce: 1) respondent burden, and 2) error associated with multiple testing. We will specifically measure usability, feasibility, and fidelity as well as teacher and student outcomes.

Student Characteristics

Goal Attainment Scaling (GAS; Ruble et al., 2010). See Phase One Measures above for a full description.

Vineland Adaptive Behavior Scales, Second Edition – Teacher (VABS-II; Sparrow et al., 1984). This assessment measures personal and social skills, and has been validated with children with developmental disabilities from birth through 18 years, 11 months. The VABS-II assesses functioning levels in four developmental domains: 1) Communication, 2) Daily Living Skills, 3) Socialization, and 4) Motor Skills. An Adaptive Behavior Composite summarizes across the four adaptive behavior domains. The VABS-II is commonly used as an outcome measure in studies of children with autism (Charman, 2004; Rogers, 1998; Troost et al., 2006). The VABS-II survey edition will be administered by telephone, paper or on-line (depending on the teacher's preference). VABS-II standard scores will be used to measure change over time in overall adaptive behavior, communication and social skills.

Cognitive ability will be measured using either the MSEL (Mullen, 1995) or the DAS-II (Elliot, 2012). See Phase One Measures above for a full description.

Educator characteristics

Demographics. At intake, data will be gathered on teacher and paraprofessional demographics including experience, education and training, age, and race/ethnicity.

Teacher Technology Integration Survey (TTIS). The TTIS is a 61 item scale that takes 15 min to complete. It measures six factors: (1) risk taking behaviors and comfort with technology; (2) perceived benefits of using technology in the classroom; (3) beliefs and behaviors around classroom technology use; (4) teacher technology use; (5) facilitation of student technology use; and (6) teacher support for technology use and access to technology. Studies support the validity and reliability of the scales and the overall measure (Vannatta & Banister, 2009)

Implementation Survey. Educators will complete an Implementation Survey at the end of the school year and at follow up which assesses the constructs of training acceptability, appropriateness, adoption and feasibility. The survey will also address general issues of comprehension of the intervention, areas of difficulty in applying the CPRT strategies in the classroom and satisfaction with all aspects of the training. Data from the IPT and OVPD groups will be compared using raw scores of Likert ratings.

Fidelity of CPRT. We will code adherence, quality and amount of use of CPRT objectively throughout the study. Fidelity of the CPRT interactive decision tree and intervention will be examined. Data on adherence to CPRT intervention strategies will be collected by video recording classroom activities (see video collection strategies below). Trained research assistants blind to study conditions or hypotheses will code the recorded observations for use of CPRT (both adherence and quality). Fidelity will also be measured by assessing educators' use of the resource materials through a monthly report of intervention use via an on-line survey. Educators will complete a very brief on-line report of use survey of their use of CPRT with their target student, use of CPRT with non-target students, the duration of CPRT use, use of the interactive decision tree, FI checklist, data sheets and other resource materials. Fidelity is measured as percent of components with a 4 or 5 (passing). CPRT Use is measured by number of students and duration of use.

Training Engagement. Data addressing engagement in training will include: the number of training sessions attended, and usage of the online tools (tracked automatically in the online system), compared across groups.

Survey of Educators Knowledge and Value of Research Based Practices for Students with Autism (Williams et al., 2011). The survey includes 52 brief statements regarding knowledge and value of the identified EBP for students with autism. Eight of the statements directly relate to strategies taught in the CPRT manual, five regarding general ABA and three regarding specific CPRT components. The list of practices was identified through an extensive literature review and using the National Standards Report (2009). Participants rate these statements using a 4-point Likert-type scale (Likert, 1932) that consists of values ranging from *not knowledgeable* to *highly knowledgeable* and from *not valuable* to *highly valuable*. Both scales have excellent reliability. We have adapted the survey to include statements about the additional five CPRT components. Raw scores will be used to examine change in knowledge and values of strategies that are part of CPRT those that are not, within and across groups.

Coach-Teacher Alliance (Bradshaw et al., 2009). At the end of the school year, educators will complete the *Measure of Coach and Teacher Alliance–Teacher Report* (Bradshaw et al., 2009; see Appendix B). The measure includes 30 items, which assess *working relationship, coaching process, investment,* and *benefits of coaching*. All items are rated on a 5-point Likert scale ranging from *Never* to *Always*. The measure has been found to measure multiple dimensions of the coaching relationship differentially (Johnson et al., 2016). Average ratings on each scale will be compared across IPT and FWBT groups.

Administrative Data. We will examine placement type and setting, attendance and behavior reports, suspensions and expulsions. (a) *Least Restrictive Environment.* This includes the proportion of time the student spends in a general education classroom; whether they receive Intensive Individual Services, and Placement Type (residential; separate school/class; regular classroom). (b) *Behavior.* Behavior scores will include the number of days a behavior incident report was filed or if the student was suspended or expelled from school. (c) *Attendance.* Attendance will be based on the number of days the student attended school during the school year. We will examine change over time in placement, behavior and attendance to pilot the use of these data for research on the scale-up of CPRT.

2.2.7. Analysis plan

The primary purpose of a pilot study is to examine feasibility, utility, and acceptability of the intervention (training procedures) in preparation for a full-scale trial. Given the small sample size, direction of effects and effect size estimation will be examined to indicate promise of the training models (Leon et al., 2011). In our prior evaluation of CPRT, an effect size of .39 was observed for teacher fidelity outcomes after receiving in-person training; a similar effect size is anticipated for the proposed training models. Though underpowered with only 10 teachers per group, repeated measures analyses of variance (ANOVA) will be utilized for pre/post quantitative measures to examine changes in teacher fidelity (percentage of components implemented from those indicated by the CPRT Decision Tree for each observation; Hypothesis 1) as well as student outcomes (GAS, Vineland, and administrative data); Hypothesis 4: A two-tailed t test will compare teacher participation, usage, satisfaction, and knowledge across IPT and FWBT training. Type I error probability will be maintained at .05 (two-tailed) for all analyses.

3. Primary outcomes

The primary outcomes will evaluate measures of implementation effectiveness at the teacher participant level, and will be focused on engagement, feasibility and acceptability, relational alliance, and fidelity and use of CPRT. Data on teacher participant engagement in the training activities and with the developed resources, including the learning modules, decision tree and associated support features will be collected through the learning resource system. These data will be used to determine individual participant and collective engagement in the pilot study training. Additionally, pre-/post-training knowledge assessments embedded within the training modules will be used to evaluate teacher knowledge gain related to the components and application of CPRT. To evaluate possible impact of training and coaching format (in-person versus fully virtual), the strength of the coach/participant relationship will be measured using the Coach/Teacher Alliance. Feasibility and acceptability of the training and coaching procedures, resources and format, and CPRT specifically, will be measured through teacher participant report. Participant teacher fidelity will be measured through coding of live and recorded observation of teachers working with their students to determine accuracy and adherence to the components of CPRT. Teachers will self-report their use of CPRT to estimate impact on instructional time and dosage students receive.

4. Secondary outcomes

The secondary outcomes will evaluate the impact of teacher training in CPRT on students. The impact of teacher participation on students will be evaluated in terms of progress toward IEP goals (using Goal Attainment Scaling), change in adaptive behavior as measured by the Vineland Adaptive Behavior Scales. We will also pilot the use of administrative data to examine student outcomes. These data will be compared with more proximal data (described above) to see if they will be appropriate for a scale up project. We will examine placement type and setting, attendance and behavior reports, suspensions and expulsions. (a) *Least Restrictive Environment.* This includes the proportion of time the student spends in a general education classroom; whether they receive Intensive Individual Services (Y/N) and Placement Type (residential; separate school/class; regular classroom). (b) *Behavior.* Behavior measures will include number of days a behavior incident report was filed or the student was suspended or expelled from school. (c) *Attendance.* Attendance will be based on the number of days the student attended school during the school year. We will examine change over time in placement, behavior and attendance to pilot the use of these data for research on the scale-up of CPRT.

5. Discussion

5.1. Innovation

The development of a decision tree to link specific components of CPRT to student characteristics, learning goals and teaching activities will allow teachers to systematically adapt CPRT to the needs of their classroom and monitor fidelity of CPRT based on those needs. This will be accompanied by distance training, developed with adult behavior change theory in mind, that includes didactic training to increase knowledge, virtual immersive practice to increase confidence, coaching to improve CPRT fidelity and interactive activities to ensure implementation in practice. We will test the necessity of in person training for learning and training engagement. This innovative package will increase CPRT fidelity, thereby increasing student motivation and responsivity and improving student outcomes.

5.2. Limitations

This study is one of the first to propose targeted EBP component analysis to inform tailored implementation guidance, however it is not without limitations. The available dataset, while substantial, characterizes students during only one school year. Additionally, the fidelity data from coded video recorded intervention sessions represents a subset of teachers who have participated in research evaluating the efficacy study of CPRT. It is possible that factors impacting CPRT use in schools more generally, will vary.

5.3. Impact

Even though teachers regularly adapt EBPs to meet the specific needs of their students and classrooms, typical practice continues to be static training in packaged intervention protocols. Teachers are provided limited information about how and when to individualize based on student needs, as there are limited empirical data to assist with this process (Stahmer et al., 2011). As a result, teachers often adapt EBPs in ways that are not likely to facilitate positive student outcomes (Howard et al., 2005).

Additionally, most training is primarily didactic with limited, if any, coaching and ongoing supervision. This is especially true when interventions are scaled up and teachers receive only an intervention manual or a one-day workshop to support their learning. On-line learning methods have traditionally been limited to knowledge-based information. However, recent advances in distance training technology and increased demand for virtual access have opened up the potential for testing innovative scale up models. Overall, distance training and coaching have great potential for scaling up evidence-based interventions by increasing access to training content and experienced coaches.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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